VINELAND CHEMICAL SUPERFUND SITE: FISH TISSUE ANALYSIS AND RISK EVALUATION FOR MAURICE RIVER AND UNION LAKE, CUMBERLAND COUNTY, VINELAND, NEW JERSEY

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EXECUTIVE SUMMARY

The Vineland Chemical site is a 54-acre manufacturing facility located in Cumberland County, New Jersey (NJ) (Figure ES-1). The facility was involved in the production of arsenical herbicides, fungicides, and biocides since 1949. Arsenical feedstock compounds were historically stored in unprotected piles that resulted in soil and groundwater contamination in the vicinity of the site. Runoff during storm events and the recharge of arsenic-bearing groundwater has contaminated the adjacent watershed, including soil, sediment, and surface waters of nearby waterways such as Blackwater Branch, Maurice River, and Union Lake (Figure ES-1). Four long-term, remedial phases at the site focus on source control, migration management, and cleanup of the rivers and Union Lake sediments, which was the subject of a Record of Decision (ROD) in 1989 [U.S. Environmental Protection Agency (USEPA) 1989a]. The current phase of remediation at the site involves removing the contaminated soils/sediments of the Blackwater Branch and the floodplain east of Mill Road and adjacent to the site.

This report presents a risk evaluation of arsenic in fish tissue collected in the Maurice River and Union Lake downstream of the Vineland Chemical Superfund Site in Vineland, Cumberland County, New Jersey. The fish collection effort was conducted in June 2009 and included collection of target fish species in three areas of Union Lake (North, Central, and South), the Maurice River below the confluence with the Blackwater Branch, and Maurice River above the confluence with the Blackwater Branch (Figure ES-2). Target predator species included largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*), and target bottom feeders included channel catfish (*Ictalurus punctatus*). If channel catfish were not present or not captured, other available catfish species in the Maurice River or Union Lake were substituted. If target predator and bottom-feeding fishes were not present in the Maurice River (or in Union Lake), sunfishes, such as bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), or redbreast sunfish (*Lepomis auritus*) were substituted. The analysis of tissue from non-target fish species (including sunfishes) was approved by USEPA prior to analysis. Largemouth bass tissue was analyzed as fillets. All other species were analyzed as whole-body fish. USEPA risk assessors requested that, in addition to inorganic (total) arsenic, speciation of arsenic in fish tissue be performed: arsenate (As5+), arsenite (As3+), monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA). Co-located sediment and water samples were also collected for total arsenic analysis.

The sampling and analytical testing of fish tissue and co-located sediment and water samples was intended to provide screening- level risk information and was conducted in accordance with the *Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP) for Vineland Chemical Superfund Site – Operable Unit#3 Blackwater Branch Area – West of Route 55: Arsenic Monitoring and Fish Tissue Study* (USACE 2009). EA Engineering, Science, and Technology, Inc. (EA) was contracted by the U.S. Army Corps of Engineers (USACE) - Philadelphia District to conduct the fish tissue collection and sediment and water sampling and to perform a risk evaluation for fish consumption. The total arsenic concentration in the sediment and water samples was measured by the U.S. Environmental Protection Agency (USEPA) Region II Laboratory located in Edison, New Jersey. Speciation of arsenic in fish tissue was performed by Brook Rand Laboratory located in Seattle, Washington. Data for each of the tested media (sediment, water, and fish tissue) were validated by USEPA Region II.

Detected arsenic concentrations in water samples were compared to the USEPA Drinking Water Criterion for arsenic of 10 parts per billion (ppb or μg/L), and the results for detected arsenic concentrations in sediment were compared to the Site Clean-up Level of 20 parts per million (ppm or mg/kg) for arsenic in solids. The Site Clean-up Level of 20 ppm is based upon the New Jersey Residential Clean-up Standard for Arsenic. Tissue data were used to: 1) document the arsenic concentrations that have accumulated in the tissue of fish that inhabit nearby waterways that have been impacted by previous operations of the site and 2) assess the potential for risk to consumers of fish from these waterways.

ES.1 ARSENIC RESULTS

Arsenic concentrations in fish tissue varied by sampling area and species. Fish species varied by sampling area because each target species and the optimal number of individual fish for each species were not found during sampling in each area. Detected arsenic concentrations were compared to a fish tissue screening value of 0.0021 mg/kg, which is based on USEPA-Region III Risk Based Concentrations (RBCs) (USEPA 2007). Each of the detected arsenic concentrations exceeded the fish tissue screening value. In general, arsenic was detected at concentrations approximately one order of magnitude lower in fish tissue from Above the Blackwater Confluence (reference site) than in the other downstream sampling sites. Three arsenic forms [As3+, As5+, and inorganic (total) arsenic] were detected frequently in both the Union Lake tissue samples and the tissue samples from Below the Blackwater Confluence. DMA and MMA were detected less frequently in the samples from Below the Blackwater Confluence and Union Lake.

Total arsenic concentrations in co-located sediment samples collected from Below the Blackwater Confluence and within Union Lake ranged from 25 mg/kg to 1,100 mg/kg and exceeded the Site Clean-up Level of 20 mg/kg. Total arsenic was not detected in the co-located sediment from Above the Blackwater Confluence or in any of the co-located surface water samples.

ES.2 RISK EVALUATION

A screening-level risk evaluation was undertaken in consultation with risk assessors from USEPA Region II to assess arsenic that has migrated downstream from the Vineland Superfund Site. The risk evaluation utilized USEPA guidance for Superfund risk assessments. This evaluation provided a risk-based estimate of potential risks from arsenic exposure through ingestion of fish from the Maurice River and Union Lake below the confluence of Blackwater Branch. The focus was on recreational anglers. Conservative assumptions were made throughout the risk evaluation to provide a reasonable maximum estimate of risks. Arsenic was detected in high levels in the fish sampled at all areas/locations. The risk estimates exceed acceptable standards (1E-4 to 1E-6 range for carcinogenic effects; 1.0 for non-carcinogenic effects) to such a degree that lowering the conservative factors in the calculations would not achieve acceptable risk levels.

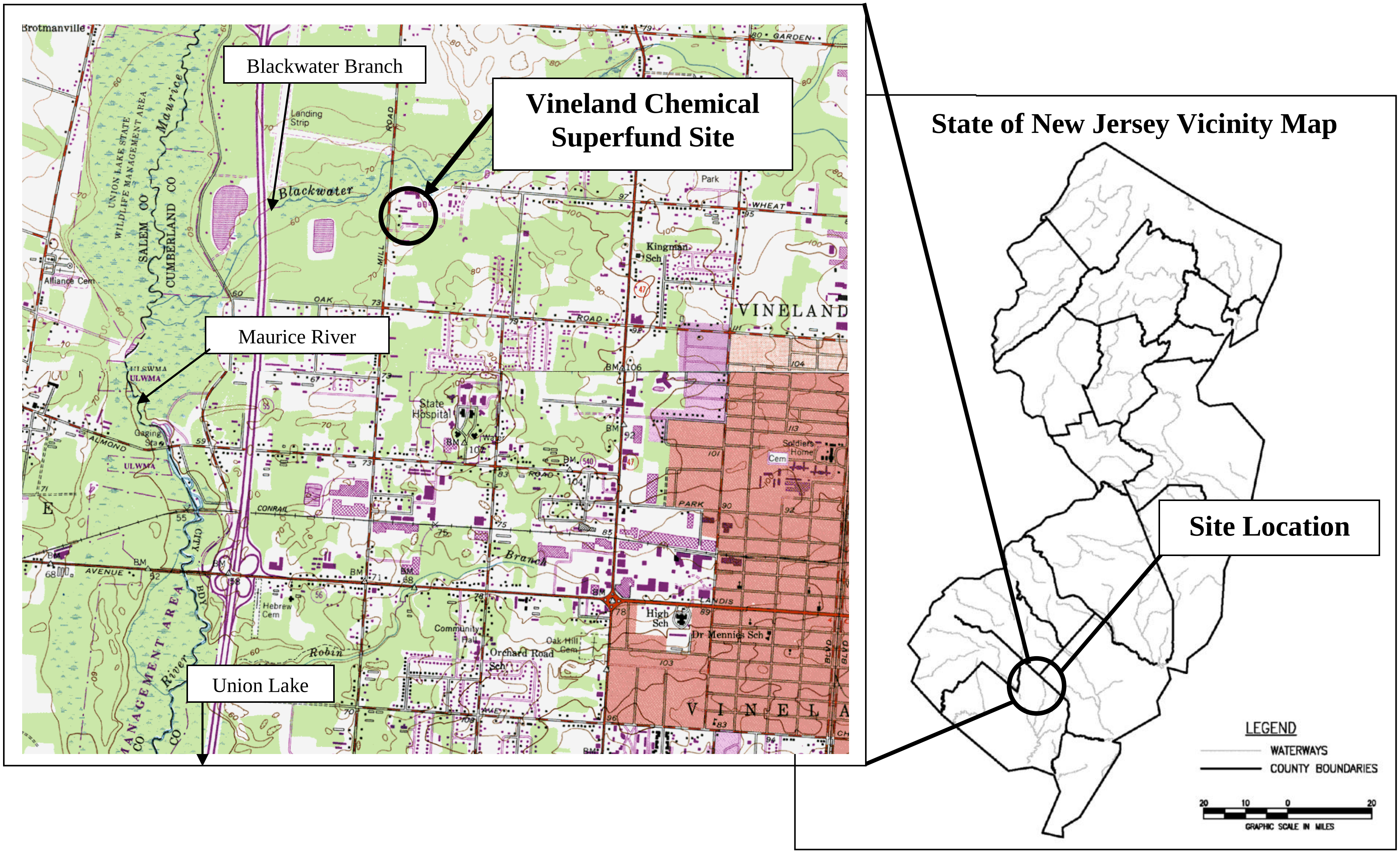

Figure ES-1. Vineland Chemical Superfund Site Location Map, Cumberland County, NJ

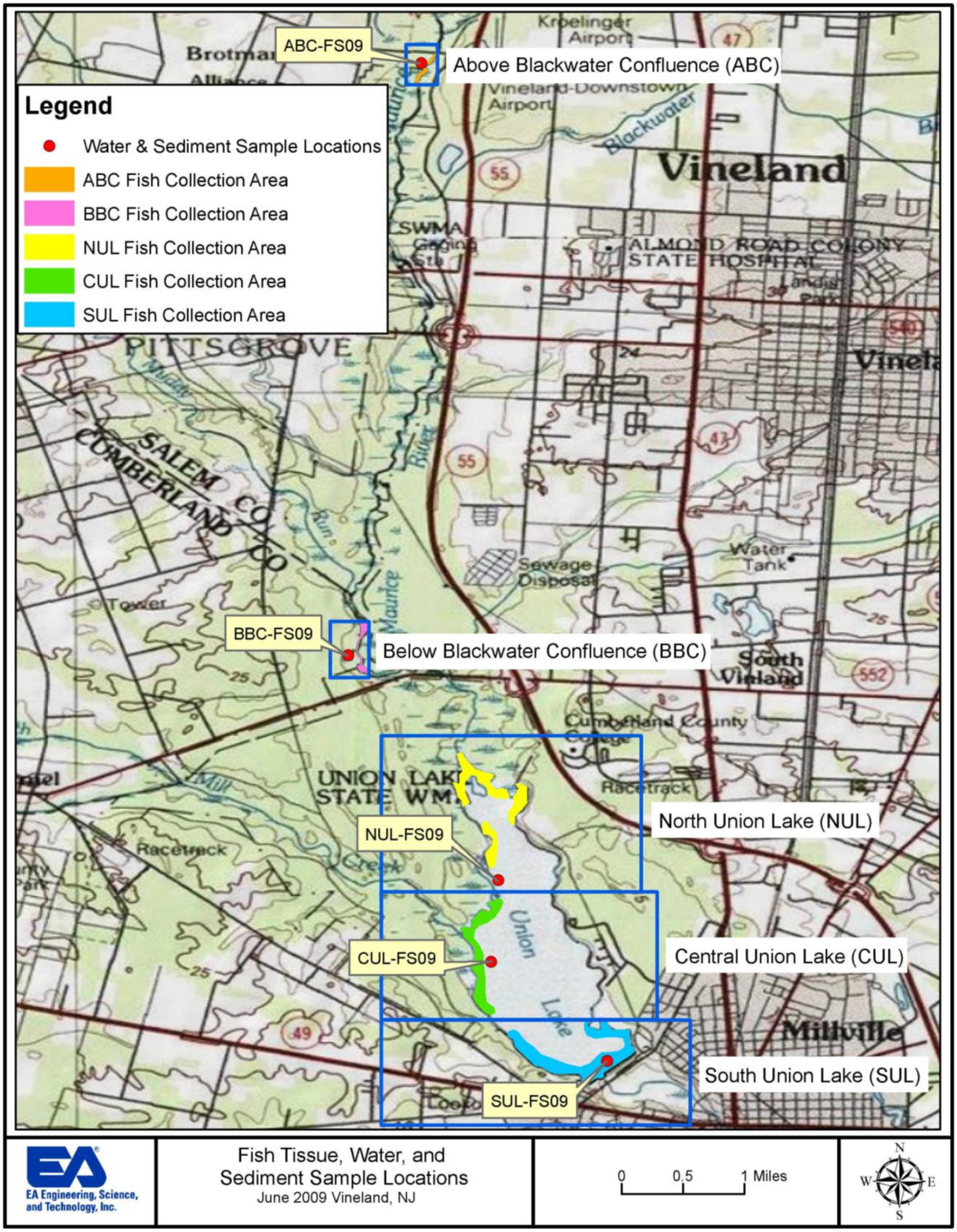

Figure ES-2. Fish tissue, sediment and water sampling sites in the Maurice River and Union Lake.

TABLE OF CONTENTS

APPENDIX A: Field Documentation and Logbook, Photologs, Fish Collection Permit, and Chain-of-Custody (COC) Forms for Arsenic Analyses

APPENDIX B: Fish Tissue Analytical Reports and Validation Report

APPENDIX C: Sediment and Water Analytical Report and USEPA Region 2 DESA Standard Operating Procedures C-116 (Preparation of aqueous TCLP extracts, soil/sediment/sludge/solid, waste oil/organic solvents, and biological tissue matrices by block digestion) and C-109 [Determination of metals in aqueous, TCLP extracts, soil/sediment/sludge/solid, waste oil/organic solvents, and biological tissue matrices by trace (axial configuration) inductively coupled plasma-atomic emission spectrometry]

APPENDIX D: Risk Based Concentration Tables

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, ACRONYMS, AND UNITS

ABC	Above Blackwater Confluence
As3+	Arsenite
As5+	Arsenate
As(Inorg)	Inorganic Arsenic
AT	Averaging Time
BBC	Below Blackwater Confluence
BGS	Bluegill Sunfish
BPJ	Best Professional Judgment
BW	Body Weight
ºC	Degrees Celsius
C	Chemical Concentration in Fish
CF	Conversion Factor
CHC	Channel Catfish
COC	Chain of Custody
CR	Ingestion Rate
CSF	Cancer Slope Factor
CUL	Central Union Lake
DESA	Division of Environmental Science and Assessment
DGPS	Differential Global Positioning System
DMA	Dimethylarsinic acid
EA	EA Engineering, Science, and Technology, Inc.
ED	Exposure Duration
EF	Exposure Frequency
EPC	Exposure Point Concentration
FS	Feasibility Study
ft	Foot/Feet
g	grams
g/day	grams per day
HNO_3	Nitric acid
IRIS	Integrated Risk Information System
LMB	Large Mouth Bass
MDL	Method Detection Limit

LIST OF ABBREVIATIONS, ACRONYMS, AND UNITS (continued)

mg/kg	Milligram(s) Per Kilogram (ppm)
mg/L	Milligram(s) Per Liter
mL	Milliliter(s)
mm	Millimeter(s)
MMA	Monomethylarsonic acid
MS/MSD	Matrix Spike/Matrix Spike Duplicate
mS/cm	Millisemens Per Centimeter
NAD83	North American Datum 1983
NJ	New Jersey
NJDEP	New Jersey Department of Environmental Protection
NJDFW	New Jersey Division of Fish and Wildlife
ND	Non-detect
NPL	National Priorities List of Superfund sites
NUL	North Union Lake
OU	Operable Unit
ppb	Part(s) Per Billion (µg/kg or µg/L)
ppm	Part(s) Per Million (mg/kg or mg/L)
ppt	Part(s) Per Thousand (g/kg or g/L)
PSS	Pumpkinseed Sunfish
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBC	Risk Based Concentration
RBS	Redbreast Sunfish
RfD	Reference Dose
RI	Remedial Investigation
RL	Reporting Limit
ROD	Record of Decision
RPD	Relative Percent Difference
SAV	Submerged Aquatic Vegetation
SOP	Standard Operating Procedure
SUL	South Union Lake
TCE	Trichlorethylene
TDL	Target Detection Limit

LIST OF ABBREVIATIONS, ACRONYMS, AND UNITS (continued)

UFP	Uniform Federal Policy
µg/L	Microgram(s) Per Liter (ppb)
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WA	Washington
WTP	White Perch
YPH	Yellow Perch
yr	Year

1. INTRODUCTION

This report presents results of a risk evaluation of arsenic in fish tissue collected in the Maurice River and Union Lake downstream of the Vineland Chemical Superfund Site in Vineland, Cumberland County, New Jersey. The fish collection effort was conducted in June 2009 and included collection of target fish species in three areas of Union Lake (North, Central, and South), the Maurice River below the confluence with the Blackwater Branch, and Maurice River above the confluence with the Blackwater Branch. The sampling and analytical testing of fish tissue and co-located sediment and water samples was intended to provide screening- level risk information and was conducted in accordance with the *Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP) for Vineland Chemical Superfund Site – Operable Unit#3 Blackwater Branch Area – West of Route 55: Arsenic Monitoring and Fish Tissue Study* (USACE 2009). These data were used to: 1) document the arsenic concentrations that may have accumulated in the tissue of fish that inhabit nearby waterways that have been impacted by previous operations of the site and 2) assess the potential for risk to consumers of fish from these waterways.

1.1 PROJECT BACKGROUND

Vineland Chemical Company manufactured arsenic-based herbicides at this facility from 1950 until 1994. The site is located adjacent to the Blackwater Branch, a tributary of the Maurice River (Figure 1-1). The Maurice River joins Union Lake about eight miles downstream of the site. The Vineland Chemical facility consisted of manufacturing and storage buildings, a laboratory, several lagoons and former chicken coops. Prior to 1977, the company stored wastes containing high levels of arsenic in the unlined lagoons and chicken coops. Preliminary sampling conducted in the early 1980s indicated that the on-site groundwater and sediments in the Maurice River were contaminated with arsenic. The Vineland Chemical Company was added to the National Priorities List of Superfund sites (NPL) in 1984.

In 1985, USEPA began a Remedial Investigation and Feasibility Study (RI/FS) to determine the nature and extent of the contamination at the on-site and off-site areas and evaluate cleanup alternatives. Based on the RI/FS, the USEPA determined that the soil at the Vineland Chemical plant was substantially contaminated with arsenic in localized areas, and in the shallow groundwater was contaminated with arsenic and to a lesser degree with cadmium and trichlorethylene (TCE). USEPA also confirmed that sediments and surface water in the Blackwater Branch, Maurice River, and Union Lake contained elevated levels of arsenic that originated from the Vineland Chemical Company site.

In 1989, after completing the RI/FS, USEPA issued a Record of Decision (ROD) with New Jersey Department of Environmental Protection (NJDEP) concurrence that selected remedial actions for each of four Operable Units (OU) that were established at the site. The ROD required the following: consolidation and treatment, by in-situ flushing, of the on-site contaminated soils (OU1); installation of an on-site ground water remediation system to extract and treat the contaminated ground water (OU2); the excavation and treatment, by flushing, of the arsenic-contaminated sediments in the Blackwater Branch and Maurice River (OU3); and the excavation and treatment, by flushing, of arsenic-contaminated sediments in Union Lake (OU4). The ROD also specified that the treated sediments from the rivers and lake be redeposited in the floodplain.

USEPA completed construction of the OU2 ground water treatment system in 2000, and the system is currently treating about one million gallons of water per day. The system is also preventing contamination from migrating off-site by establishing hydraulic control over the ground water. The Remedial Design for a soil flushing system for OU1 was completed in 2001. Plant site excavation and soil washing began in earnest in 2003 and was completed in December 2007. Along with the Plant Site soils, the first phase of the OU3 River Areas was completed. This included the excavation and soil washing of sediments from the Blackwater Branch, east of Mill Road. The Remedial Design for the remaining OU3 Blackwater Branch work is underway. The Maurice River cleanup implementation is pending the outcome of the Blackwater Branch work and study of the riverine system for up to three years

Actions and funds for the Remedial Design of OU4 are also pending; however, the ROD calls for a three-year waiting period after the remediation of OU1 and OU3 before initiation of the Remedial Design to allow for natural flushing of the river system after the source of the contamination has been removed. In addition to the three-year delay prior to the initiation of the Remedial Design, the ROD calls for a period of monitoring and sampling of the Blackwater Branch and Union Lake during this time to determine the impacts of the remediation of OU1 and OU2 on these water bodies. These data are to be used to determine if the remedial activities have affected water, sediment, or fish in the Blackwater Branch or Union Lake.

The first two years of monitoring and sampling were completed in 2006 and 2007. Based on the first two years of monitoring sediment and surface water, it was determined that fish in the adjacent waterways may have been exposed to elevated levels of arsenic in sediment, and consequently an additional sampling task to collect fish tissue samples and co-located sediment and surface water samples was performed during the third year (2009) of monitoring and sampling.

1.2 PROJECT LOCATION

The Vineland Chemical site is a 54-acre manufacturing facility located in Vineland, Cumberland County, NJ (Figure 1-1). The site is located in south-central NJ, approximately 40 miles from Wilmington, Delaware and approximately 35 miles from Atlantic City, NJ. The facility was involved in the production of arsenical herbicides, fungicides, and biocides since approximately 1949. Arsenical feedstock compounds were historically stored in unprotected piles. This resulted in soil and groundwater contamination in the vicinity of the site. Runoff during storm events and the recharge of arsenic-bearing ground water has contaminated the adjacent watershed, including nearby waterways such as Blackwater Branch, Maurice River, and Union Lake.

1.3 PROJECT PURPOSE AND OBJECTIVES

The purpose of this project was to evaluate arsenic levels in fish tissue in support of environmental studies of the migration of elevated arsenic levels downstream of the Vineland

Chemical Company Superfund Site. Previous studies of sediments within the Blackwater Branch, a tributary of the Maurice River and upstream of Union Lake, have exhibited elevated levels of arsenic. This project will determine if aquatic biota, namely fish, have accumulated arsenic in their tissues to concentrations that may be harmful to human consumers of the tissue.

This data collection effort was performed consistent with the Vineland ROD to satisfy the need for monitoring and sampling for a specified period of time subsequent to remediation of OU1 and ongoing operations of OU2 and OU3. Fish were targeted for collection at five locations along a sampling gradient: one background/reference area in the Maurice River upstream of the confluence with the Blackwater Branch and upstream of the area of potential contamination; one area within the Maurice River downstream of the confluence with the Blackwater Branch; and three locations within Union Lake distributed from the north end near where the Maurice River enters the lake and spaced throughout the lake in a southward direction (three geographic zones – north, central, and south) (Figure 1-2). By spacing the sampling locations downstream from the source of contamination, a gradient of contamination within the fish communities, if any, can be established.

The fish tissue sampling and analysis and risk evaluation consisted of the following tasks:

- Collection of fish tissue from five locations (geographic areas) in the Maurice River and Union Lake;

- Testing of fish tissue for inorganic (total) arsenic, arsenate (As5+), arsenite (As3+), monomethylarsonic acid (MMA) and dimethylarsinic acids (DMA). ,

- Collection of co-located sediment and surface water samples;

- Testing of sediment and water samples for total arsenic;

- Screening-level risk evaluation of arsenic concentrations measured in the fish tissue; and

- Data report preparation and submittal.

1.4 EXPERIMENTAL DESIGN

The executing agency for this project is the U.S. Army Corps of Engineers (USACE), North Atlantic Division, Philadelphia District. This investigation was designed to identify, analyze, and evaluate the arsenic concentrations in fish tissue, sediments, and water collected in waterways located adjacent to and downstream of the site. EA Engineering, Science, and Technology, Inc. (EA) was contracted by the USACE - Philadelphia District to: 1) collect fish tissue and co-located sediment and surface water samples in the Maurice River and Union Lake, and 2) to conduct a screening-level risk evaluation. Speciated arsenic concentrations were measured by Brooks Rand Laboratory in Seattle, Washington. Total arsenic concentrations in the sediment and water samples were measured by the USEPA Region II Division of

Environmental Science & Assessment (DESA) Laboratory located in Edison, NJ. The data gathering methods for the project followed guidance provided by the UFP QAPP (USACE 2009), and the sediment, water, and fish tissue data were validated by the USEPA Region II DESA Laboratory.

Target predator species included largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*), and target bottom feeders included channel catfish (*Ictalurus punctatus*). If channel catfish were not present or not captured, other available catfish species in the Maurice River or Union Lake were substituted. If target predator and bottom-feeding fishes were not present in the Maurice River (or in Union Lake), sunfishes, such as bluegill (*Lepomis macrochirus*) or pumpkinseed sunfish (*Lepomis gibbosus*) were substituted. The analysis of tissue from non-target fish species (including sunfishes) was approved by USEPA prior to analysis. Largemouth bass tissue was analyzed as fillets. All other species were analyzed as whole-body fish.

1.5 REPORT ORGANIZATION

This report contains a comprehensive summary of field activities, results of the fish tissue and co-located sediment and water sample analyses, and results of a screening-level human health risk evaluation for arsenic on fish tissue. Field sampling techniques and analytical methodologies for arsenic analyses are provided in Chapter 2, and results of the arsenic analyses are provided in Chapter 3. The risk evaluation procedures and results are documented in Chapter 4. References cited are provided in Chapter 5.

Appendix A presents a copy of the field logbook, field data sheets, fish collection permit, photologs for each geographic area, and chain-of-custody (COC) forms for the submitted samples. Appendix B presents the analytical results and validation report from the arsenic analyses on fish tissue, and Appendix C presents the analytical results for the arsenic analysis on sediment and water samples. Appendix D provides a copy of the Risk Based Concentrations (RBC) table used in the risk assessment.

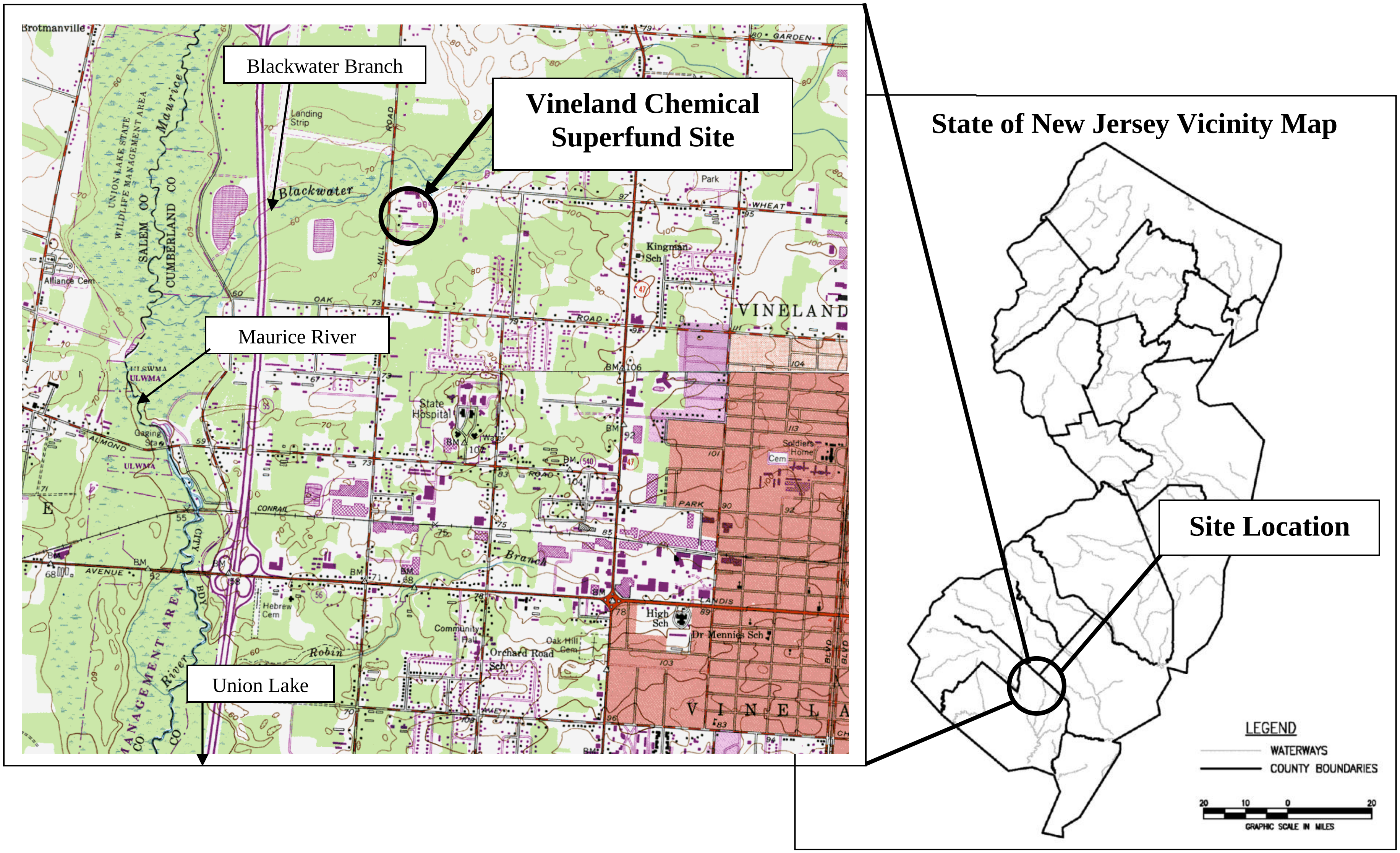

Figure 1-1. Vineland Chemical Superfund Site Location Map, Cumberland County, NJ

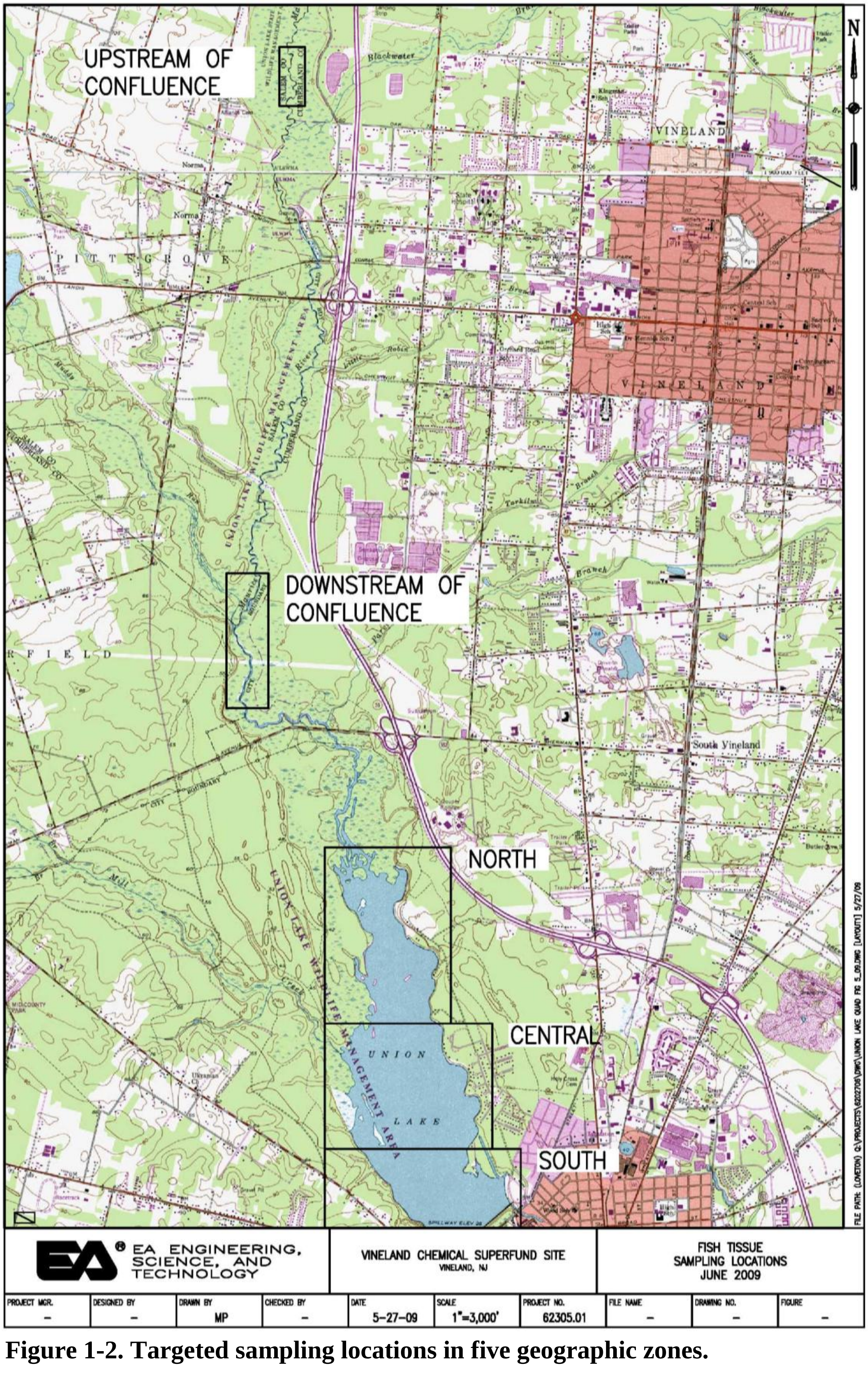

Figure 1-2. Targeted sampling locations in five geographic zones.

2. METHODOLOGY

The sampling and analytical testing of fish tissue and co-located sediment and water samples was conducted in accordance with the *Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP) for Vineland Chemical Superfund Site – Operable Unit#3 Blackwater Branch Area – West of Route 55: Arsenic Monitoring and Fish Tissue Study* (USACE 2009). Fish collection and sampling of sediment and water was conducted during the period of 09 June to 25 June 2009. Analytical testing of sediment, water, and tissue was conducted in July-August 2009.

2.1 SAMPLING OBJECTIVES

The sampling effort included fish tissue collection and co-located surficial sediment and surface water sampling. The overall objectives of the field sampling were to:

- Collect target fish species in each if the five geographic areas using active and passive collection techniques (as necessary to collect sufficient species, sizes, and numbers of fish for chemical analysis);
- Record total length and weight information for each fish to allow for appropriate creation of composite tissue samples;
- Designate multiple fish of target length for tissue composite samples;
- Freeze, package, and submit fish to the analytical laboratory for homogenization, preparation of composite samples, and analytical testing;
- Collect one sediment sample and one co-located surface water sample in each of five geographic areas for total arsenic analysis;
- Transfer sediment and water samples to appropriate, laboratory-prepared containers and preserve/hold samples for analysis according to protocols that ensure sample integrity;
- Measure and record *in situ* water quality information (temperature, conductivity, salinity, dissolved oxygen, and pH) at each surface water sampling location;
- Submit equipment blanks, duplicates, and matrix spike (MS) / matrix spike duplicates (MSDs) for analytical testing (for sediment and water); and
- Complete appropriate COC documentation.

2.2 SAMPLING LOCATION DETERMINATION

Geographic sampling areas were chosen in consultation with USEPA and USACE-Philadelphia District. The specific areas sampled for fish within each of the five geographic zones were determined in the field and represented those areas with habitat (depth, substrate, and aquatic vegetation) most conducive to or optimal for supporting or providing refuge for target fish species (Figure 2-1). Co-located sediment and water samples were collected at one location in each geographic area where the majority of fish were collected (Figure 2-1). Northing and easting coordinates [NJ State Plane North American Datum 1983 (NAD83)] are provided for each sediment/water sampling location in Table 2-1. Positioning in the field was determined using a Trimble ProXR Differential Global Positioning System (DGPS), which utilizes the United States Coast Guard Differential Beacon System to obtain sub-meter accuracy. A brief description of each sampling area and fish collection techniques utilized is included below:

Sample Location:	**Description of Sampling Location and Fish Collection Methods Used:**
1) Above Blackwater Branch Confluence (ABC)	Maurice River above the confluence with Blackwater Branch and downstream of the Garden Road Bridge (Figure 2-1). This area was intended to represent a reference area or area that was not previously impacted by arsenic concentrations originating from the Vineland Chemical Superfund Site. Electrofishing methods were utilized to collect fish from all available habitat in this area. Photos are provided in Appendix A.
2) Below Blackwater Branch Confluence (BBC)	Maurice River below the confluence with Blackwater Branch. This area was intended to represent the river habitat downstream of the confluence and potentially impacted by the Vineland Chemical Superfund Site. Electrofishing methods were utilized to sample submerged aquatic vegetation (SAV), emergent vegetation, woody debris, pools, undercut banks, and other likely fish habitat. Photos are provided in Appendix A.
3) North Union Lake (NUL)	This area consisted of the northern end of the lake where the Maurice River flows into the lake and as determined by the area represented on Figure 2-1. Optimal fish habitat was present in the northern most area of this region where a substantial area of emergent vegetation, overhanging trees, and woody debris was present. Electrofishing, gillnets, and jug-lines were utilized in this area to collect fish tissue. Photos are provided in Appendix A.
4) Central Union Lake (CUL)	This area consisted of the central portion of the lake as determined by the area represented on Figure 2-1. Fish habitat was optimal in this area mainly along the western shore where the Mill Creek tributary enters the lake. Fish habitat in this area consisted of several small islands, emergent vegetation, overhanging trees, and woody debris. Electrofishing, gillnets, and jug-lines were utilized in this area to collect fish tissue. Photos are provided in Appendix A.
5) South Union Lake (SUL)	This area consisted of the southern portion of the lake to the dam as determined by the area represented on Figure 2-1.

5) South Union Lake (SUL) (continued)	Fish habitat was less than optimal in this portion of the lake as very shallow shoreline areas prevailed. Areas with quality habitat were located around the rock structure of the earthen dam and in some woody debris near the dam. Depth contours in this portion of the lake also provided some fish habitat. Electrofishing, gillnets, jug-lines, and rod and reel were utilized in this area to collect fish tissue. Photos are provided in Appendix A.

2.3 FISH COLLECTION METHODS

Fish collection techniques were standardized within the lake system sampling and independently in the river system sampling to optimize the recovery of tissue among the trophic levels being collected for tissue analysis. Sample times varied at each station as did time expended in collecting organisms suitable for tissue analysis composites. Prior to sampling, EA applied for and received a fish collection permit from the New Jersey Division of Fish and Wildlife (NJDFW). NJDFW specified that electrofishing was not permitted during the period of 31 October through 05 May and that a report describing the number of fish caught, species obtained, and lengths and weights of each fish caught be submitted to NJDFW by 31 December 2009. A copy of the collection permit and the report submitted to NJDFW is provided in Appendix A.

2.3.1 Union Lake

Three collection techniques were employed at each of the Union Lake sampling areas (north, central, and south). Primarily, electrofishing was conducted using a boat mounted Coffelt VVP-15 electrofishing unit providing rectangular pulsed 600 volt DC electricity at approximately 4500 watts. Likely (optimal) habitat areas were selected and shocked to collect fish species required for tissue analysis. The electrofishing boat was motored along shoreline areas, aquatic vegetation beds, downed trees, depth contours and other quality fish habitat sites. Stunned fish were netted and placed in an aerated holding tank onboard the vessel to recover. Periodically, fish in the holding tank were identified and measured to the nearest millimeter total length and weighed to the nearest gram. Incidence of parasites, disease, and other morphological anomalies, if any, were noted in the field notebook. Selected voucher specimens (chain pickerel and lepomus hybrid) were preserved in 10 percent buffered formalin for laboratory confirmation of identification, whereas all other specimens were released onsite. Species preserved in the field (voucher specimens) were then transferred to 40% isopropyl alcohol in the laboratory until identified and recorded on laboratory bench sheets and integrated into the field data. Photographs were taken at each of the sampling stations (Appendix A). Fish that met or potentially met the criteria for use in a fish tissue composite sample were retained in ice until processing at the end of each field day. Fish not slated for use in tissue analysis were returned to the waterbody.

Because electrofishing alone did not provide adequate numbers of individuals or species required for tissue analysis, two additional passive collection techniques were employed. Two experimental gill nets (200'x 6' with 5 panels of mesh sizes as follows: ¾", 1", 1.5", 2", and 2.5") were deployed in deeper areas of the lake to collect pelagic and bottom dwelling fishes.

Gill nets were deployed during daylight and night time to optimize the collection of adequate tissue samples. In addition, static lines (jug-lines) were fished in likely areas primarily in an attempt to catch catfish species for tissue composites. As with the electrofishing effort, captured fish were identified, enumerated and assessed for their use in a tissue composite sample. Adequate fish were selected for sample use and the remainder returned to the lake.

2.3.2 Maurice River

Fish collection efforts employed at the Maurice River sampling sites were limited to small boat electrofishing using a reduced output boat mounted Smith-Root 1.5 KVA electrofishing unit. This unit provides pulsed DC electricity from 0 to 560 volts and 1,700 watts. Size of the waterbody, depths, flow, and recreational use precluded the use of nets and jug-lines at these stations. Quality habitat areas were sampled against the flow to collect adequate species for tissue composite samples. At times, habitat was re-sampled going with the current flow and in some areas, the entire channel was sampled. Stunned fish were netted and placed in an aerated holding tank onboard the vessel to recover. As with the lake stations, fish in the holding tank were identified and measured to the nearest millimeter total length and weighed to the nearest gram. Incidence of parasites, disease, and other morphological anomalies, if any, were noted on field data sheets. Selected voucher specimens (tadpole madtom, chain pickerel, pirate perch, tessellated darter, bluespotted sunfish, redbreast sunfish) were preserved in 10 percent buffered formalin for laboratory confirmation of identification, whereas all other specimens were released onsite. Species preserved in the field (voucher specimens) were then transferred to 40% isopropyl alcohol in the laboratory until identified and recorded on laboratory bench sheets and integrated into the field data. Photographs were taken at each of the sampling stations (Appendix A). Fish that met or potentially met the criteria for use in a fish tissue composite sample were retained in ice until processing at the end of each field day. Fish not slated for use in tissue analysis were returned to the waterbody.

2.4 FISH TISSUE HANDLING AND PROCESSING

Fish samples were handled in accordance to protocols in the *EPA Guidance for Assessing Chemical Contamination Data for Use in Fish Tissue Advisories Volume I: Fish Sampling and Analysis* (USEPA 2000). Fish that were saved for tissue samples were assigned an ID, measured for length and weight, and rinsed with deionized water. This information was recorded on field data sheets (Appendix A). Each fish was placed in an individual ziplock bag with a waterproof label indicating the sample ID. Fish were placed on ice after collection and were frozen at the end of each work day.

2.4.1 Composite Designation

Three replicate fish composites were targeted for each species for arsenic analysis for each sampling area. When sampling was completed at a location, individual fish were assigned to replicate composites. Between three and five individual fish were assigned to each replicate composite and up to three replicate composites were designated per species and location. Individual fish submitted for each composite were of similar size and age class. The smallest individual fish of a species collected and analyzed for each location was no less than 75% of the total length of the largest fish for that species. Individually bagged fish designated for each composite were placed together in one large ziplock bag for shipping. Another waterproof label with the composite ID was enclosed in the large ziplock bag. Filleting (as applicable for largemouth bass), tissue homogenization, and compositing of the fish were conducted by the analytical laboratory (Section 2.4.4).

2.4.2 Tissue Sample Labeling

A sample numbering system was used to indicate where individual fish and composites were collected, the species collected, and the sample processing required at the analytical laboratory.

Sample IDs contained the following abbreviations:

Station location	=	ABC (Above Blackwater Confluence) BBC (Below Blackwater Confluence) NUL (North Union Lake) CUL (Central Union Lake) SUL (South Union Lake)
Sampling Year	=	09
Fish Species	=	LMB (Large Mouth Bass) CHC (Channel Catfish) BGS (Bluegill Sunfish) PSS (Pumpkinseed Sunfish) RBS (Redbreast Sunfish) YPH (Yellow Perch) WTP (White Perch)
Fillet or Whole Body Processing in the Lab	=	F (Fillet) – Largemouth Bass only WB (Whole Body)
Individual Sample No.	=	001 through 030 (referenced to field data sheet)
Composite Sample No.	=	COMPA, COMPB or COMPC (three replicate composites A,B,C were targeted per species)

For example, BBC09-RBS-WB-003 was the third redbreast sunfish measured from Below the Blackwater Confluence and the whole body of the fish was used in the composite at the analytical laboratory. NUL09-LMB-F-COMPA was composite replicate A of largemouth bass from North Union Lake and each fish in the composite was filleted at the analytical laboratory.

2.4.3 Fish Tissue Shipping

Fish tissue samples were frozen until shipped. The samples were shipped overnight on dry ice to Brooks Rand Laboratory in Seattle, Washington on 29 June 2009. Chain-of-custody (COC) documentation was prepared with each individual sample ID and the composite sample IDs and was submitted with the tissue samples. Copies of the COC forms are available in Appendix A. Samples were shipped to the address below:

Brooks Rand Laboratory
3958 6th Avenue NW
Seattle, WA 98107

Fish were received frozen at Brooks Rand on 30 June 2009 and 1 July 2009.

2.4.4 Fish Tissue Preparation, Homogenization, and Compositing

Fish tissue was prepared, homogenized and composited according to Brooks Rand Standard Operating Procedure (SOP BR-0106) and USEPA Standard Methods (EPA 823-B-007). All pre and post homogenization weights of the samples were recorded on the homogenization bench sheets provided in Appendix B. Once thawed, the biota samples were homogenized individually using pre-cleaned commercial grade homogenization equipment. For compositing, approximately 20 grams of homogenized biota sample was used in each composite sample. Remaining homogenized sample for each individual fish and for each created composite was retained, frozen, and archived at the laboratory for subsequent analysis, if necessary. All skin was removed prior to filleting of largemouth bass samples.

It should be noted some of the catfish samples were too large to process with the lab's standard homogenization equipment. In an effort to remove large bone material that would not pass through the homogenization equipment, Brooks Rand requested, and received approval by the client via email on 09 July 2009, to remove the heads of the large catfish samples, prior to homogenization.

2.4.5 Fish Tissue QA/QC Samples

Equipment blanks were collected to determine the extent of contamination, if any, from the sampling and processing equipment used as part of the project. During fish tissue homogenization, several equipment blanks were collected and batched for analysis. The equipment banks for the homogenization process were analyzed for inorganic (total) arsenic [As(Inorg)], and if a non-detect was achieved, no additional analyses were performed.

A matrix spike (MS) is a field sample to which a known amount of analyte is added before sample preparation and analysis to evaluate the potential effects of matrix interference. Analyte concentrations in the spiked and unspiked sample are used to calculate percent recovery as a measure of matrix interference. A matrix spike duplicate (MSD) is a duplicate of the MS sample. Four additional volumes of tissue were tested from random composites for MS/MSD analysis.

Additionally, six composite tissue samples were run in duplicate.

2.5 CO-LOCATED SEDIMENT AND WATER SAMPLE COLLECTION, STORAGE, AND TRANSPORT

Upon completion of sample collection, samples were shipped via overnight delivery to the USEPA Region II Laboratory in Edison, NJ for arsenic analyses. Samples were shipped on ice and maintained at 4° Celsius. COCs accompanied the samples and documented the dates and times of sample collections for arsenic analyses are included in Appendix A. Samples were received at the USEPA laboratory on 1 July 2009 for arsenic analyses.

2.5.1 Surface Water Samples

Surface water samples were collected from five discrete locations. At each location, the water sample was collected as a mid-water column sample. Water samples were collected using an ISCO peristaltic pump with dedicated Tygon tubing. Water samples were transferred directly to pre-cleaned 250 ml plastic bottles preserved with nitric acid. Samples were kept on ice and maintained at 4° Celsius.

2.5.2 Sediment Samples

The sediment samples (0-0.5 ft depth increment beneath the water/sediment interface) were collected using a decontaminated stainless-steel Ponar grab sampler. Samples were homogenized in the field using stainless steel bowls and spoons immediately following sample collection. The homogenized sediment samples were then transferred directly to 4 ounce glass jars; samples were kept on ice and maintained at 4° Celsius. The stainless steel bowls and spoons were decontaminated following the process described in Section 2.6.

2.5.3 Equipment Blanks

Equipment blanks were collected to determine the extent of contamination, if any, from the sampling equipment used to collect the sediment and water samples. Three equipment blanks (Table 2-1) were collected: two blanks for the grab sampler (one for each day it was used) and one blank for dedicated water collection equipment (i.e., water pump tubing).

Equipment blanks were collected by pouring deionized water, which is provided by EA's Ecotoxicology Laboratory, over sampling equipment that was decontaminated using the procedure outlined in Section 2.5.6. The rinsate water was placed in laboratory-prepared containers, submitted to the analytical laboratory, and tested for the same chemical parameters as the sediments and site water (total arsenic). Equipment blanks were sent with the surface water and sediment samples to the USEPA Region II laboratory for arsenic analyses.

2.5.4 Field Duplicates

Field duplicate samples were collected simultaneously from the same sampling locations as sediment and water samples and are used as measures of matrix homogeneity and sampling precision (Table 2-1). A total of two duplicate samples (one sediment and one water) were collected as individual co-located samples, and they were homogenized separately. The field duplicate samples were collected at randomly selected locations.

2.5.5 Matrix Spike / Matrix Spike Duplicate Samples

A matrix spike (MS) is a field sample to which a known amount of analyte is added before sample preparation and analysis to evaluate the potential effects of matrix interference. Analyte concentrations in the spiked and unspiked sample are used to calculate percent recovery as a measure of matrix interference. A matrix spike duplicate (MSD) is a duplicate of the MS sample. Additional volumes of sediment and water were collected at random locations and included one set of MS/MSD for sediment and one set for water samples (Table 2-1).

2.5.6 Equipment Decontamination Procedures

Equipment that came into direct contact with sediment during sampling was decontaminated prior to deployment in the field and between sampling stations to minimize cross-contamination. This included the stainless-steel Ponar and stainless steel bowls and spoons. While performing the decontamination procedure, phthalate-free nitrile gloves were used to prevent phthalate contamination of the sampling equipment or the samples.

The decontamination procedure is described below:

- Rinse equipment using clean tap or site water
- Wash and scrub with non-phosphate detergent (Alconox or other laboratory-grade detergent)
- Rinse with tap water
- Rinse with 1 percent nitric acid (HNO_3)
- Rinse with distilled or de-ionized water
- Rinse with methanol followed by hexane
- Rinse with distilled or de-ionized water

Waste liquids were contained during decontamination procedures and transferred to EA's facility in Sparks, Maryland, for disposal.

2.5.7 Chain-of-Custody and Documentation

2.5.7.a Field Logbook

Field notes were recorded in a permanently bound, dedicated field logbook. A log of sampling activities and station locations were recorded in the log in indelible ink. Personnel names, local weather conditions, and other applicable field sampling program information were also recorded.

Sample location coordinates, approximate water depth, water quality, and weather conditions at each sampling location were recorded. Information was recorded in indelible ink. Documentation was initiated by the author and dated. Corrections to documentation were made with a single line through the error and with the author's initials and date. Copies of the project logbook are provided in Appendix A.

2.5.7.b Sample Identification

A sample numbering system was utilized for the sediment and water samples. The sample numbering system provided communication between the sample processing operation and the laboratory performing the desired analyses. Surface water and sediment samples were identified by site name, sample type, and date of collection. See table below for sample identification by locations:

Sample Location:	**Sample Identification:**
Above Blackwater Confluence	ABC-FS09-
Below Blackwater Confluence	BCC- FS09-
North Union Lake	NUL- FS09-
Central Union Lake	CUL- FS09-
South Union Lake	SUL- FS09-

FS09 indicated that the samples were taken as part of the fish survey (FS) in 2009 (09). The following sample descriptors were then used to denote sample types:

- SED – sediment sample;
- WAT – water sample;

For example, sample NUL-FS09-SED indicated a sediment sample collected at North Union Lake.

Field duplicates were designated with –FD at the end of the sample ID and were taken at the same time as the original sample at a particular location. MS/MSD sediment and water samples were designated with identifiers added after the site name and sample type. The following descriptors were used for matrix spike and matrix spike duplicate samples:

- MS – matrix spike sample
- MSD – matrix spike duplicate

Equipment blanks were identified by type of blank and date (Table 2-1). For example, EQBSEDGRAB-062409 represented the equipment blank taken with the sediment grab sampler (ponar) on 24 June 2009. Equipment blanks were taken each day the ponar was used to sample sediment. One equipment blank was taken for the dedicated tubing used to sample the water. The following descriptors were used to denote equipment blanks:

- EQBSEDGRAB – Ponar grab sampler
- EQBWAT – dedicated tygon tubing blank for water sampling

2.5.7.c Sample Labels

Sample containers for the surficial sediment and water samples were labeled with the following information:

- Client name
- Project number

- Sample ID
- Station location
- Date and time of collection
- Sampler's initials
- Type of analyses required

2.5.7.d Chain-of-Custody Records

Sediment and water samples collected in the field were documented on a COC form. This COC accompanied the samples to the analytical laboratory. The COC indicated the date and time of sample collection and was signed by appropriate personnel. Copies of the COCs that accompanied the analytical testing for arsenic are provided in Appendix A.

2.6 SAMPLE VOLUME REQUIREMENTS

The sample volume requirements are detailed in Table 2-2 for arsenic analyses. Arsenic analysis of sediments required 250 grams of sediment per sample. Water samples required 250 milliliters (ml) per sample for arsenic analysis. Fish tissue analysis required a minimum of 200 grams.

2.7 *IN SITU* WATER QUALITY MEASUREMENTS

Water quality measurements were recorded *in situ* at each of the sediment and water collection locations using a YSI water quality probe. Measurements were recorded at the same locations where water samples were collected for chemical analysis (mid-stream/mid-depth of the water column). The following parameters were recorded in the field log book:

- Sampling location number
- Sampling data and time
- Station coordinates
- Station depth
- Weather conditions
- Water temperature [degrees Celsius(°C)]
- Conductivity (mS/cm)
- pH
- Dissolved oxygen [milligrams per liter (mg/L)]
- Turbidity

A summary of the water quality data is provided in Table 2-1. Copies of the field logbook are provided in Appendix A.

2.8 ANALYTICAL METHODS

Analytical testing for total arsenic in sediment and water was conducted by the USEPA Region II DESA Laboratory Branch located in Edison, NJ. Inorganic (total) arsenic analysis and speciation of arsenic in fish tissue [arsenate (As^{5+}), arsenite (As^{3+}), monomethylarsonic acid

(MMA) and dimethylarsinic acid (DMA)] was conducted by Brooks Rand Laboratory in Seattle, WA.

2.8.1 Analytical Methods, Laboratory Quality Control, and Detection Limits

Co-located sediment and water samples were analyzed for total arsenic using extraction procedure DESA SOP C-116 and analysis procedure DESA SOP C-109. Tissue samples were analyzed using EPA Method 1632. Table 2-2 summarizes analytical information (total number of samples, QA/QC samples, sample volumes, sample holding times, and preservatives) for the project. The target detection limits (TDL)/screening values and laboratory reporting limits (RL) for arsenic in the water, sediment, and tissue samples were as follows:

Matrix	Target Detection Limit (TDL) / Screening Value for Arsenic	Laboratory Reporting Limit (RL) for Arsenic
Water	10 ppb (USEPA Drinking Water Criterion)	Total Arsenic: 8 µg/L (ppb)
Sediment	20 ppm (Site Clean-up Level)*	Total Arsenic: 0.73 to 0.8 mg/kg (ppm)
Tissue	0.0021 mg/kg** (ppm)	Inorganic (total) Arsenic: 0.010 mg/kg (ppm) As3+: 0.015 mg/kg (ppm) As5+: 0.015 mg/kg (ppm) MMA: 0.015 mg/kg (ppm) DMA: 0.010 mg/kg (ppm)

**The Site Clean-up Level of 20 ppm is based upon the New Jersey Residential Clean-up Standard for Arsenic.*
***The project action limit is based on USEPA Region III fish Risk Based Concentrations (RBCs) which are based on a cancer risk of 1 x 10^{-6}. Found at http://www.epa.gov/reg3hwmd/risk/human/pdf/fish.pdf and located in Appendix D. The fish RBC does not differentiate between the different arsenic speciation, and the inorganic (total) arsenic RBC has been uniformly applied.*

Copies of the USEPA Region II DESA Laboratory Branch SOPs for sample digestion and for analysis of metals are provided in Appendix C, as well as laboratory Quality Control (QC) and Quality Assurance (QA) procedures. Sample homogenizing and compositing information as well as QA/QC procedures for Brooks Rand Laboratory are provided in the analytical reports in Appendix B.

2.8.2 Data Validation

Data validation was conducted by the USEPA Region II for the inorganic (total) arsenic analysis and the fish tissue arsenic speciation. A copy of the validation report for the fish tissue is provided in Appendix B. Validation for the sediment and water samples was integrated into the DESA analytical report that is provided in Appendix C.

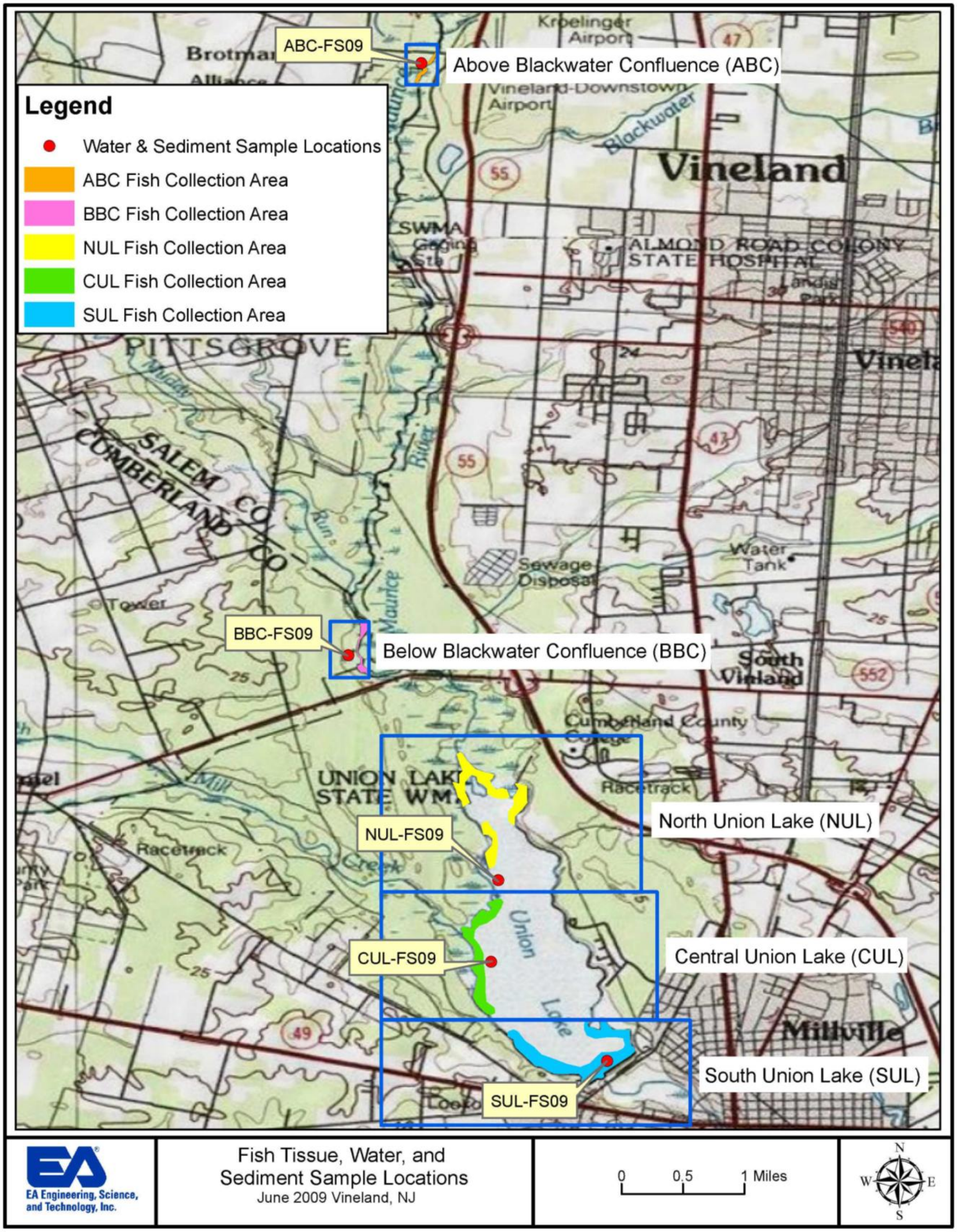

Figure 2-1. Fish Tissue, Sediment, and Water sampling sites in the Maurice River and Union Lake.

TABLE 2-1. SEDIMENT AND WATER SAMPLING LOCATIONS AND *IN SITU* WATER QUALITY PARAMETERS

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Sample ID	Sample Date/Time	Location Coordinates New Jersey State Plane, NAD83 Northing (ft)	Location Coordinates New Jersey State Plane, NAD83 Easting (ft)	Water Depth (ft)	Water Quality at Mid-Depth pH	Temperature (°C)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
ABC-FS09-WAT	6/25/09, 1458	250505.4	330966.0	3.5	6.6	22.0	153	8	0
ABC-FS09-SED	6/25/09, 1451								
BBC-FS09-WAT	6/24/09, 1530	225265.5	329358.3	< 5	7.2	21.7	145	8.7	9.6
BBC-FS09-SED	6/24/09, 1540								
NUL-FS09-WAT, NUL-FS09-WAT-FD	6/25/09, 1007	214581.5	334158.4	10	7.8	21.9	160	8.7	13.4
NUL-FS09-SED, NUL-FS09-SED-FD	6/25/09, 1013								
CUL-FS09-WAT	6/25/09, 1030	210060.0	333984.4	11.5	7.5	22.4	161	8.7	11.6
CUL-FS09-SED	6/25/09, 1040								
SUL-FS09-WAT, SUL-FS09-WAT MS/MSD	6/25/09, 1048	207490.2	336280.9	18.5	7.3	22.2	169	8.6	10.5
SUL-FS09-SED, SUL-FS09-SED MS/MSD	6/25/09, 1054								
Equipment Blanks									
EQBSEDGRAB-062409	6/24/09, 1943	--	--	--	--	--	--	--	--
EQBWAT-062409	6/24/09, 1952	--	--	--	--	--	--	--	--
EQBSEDGRAB-062509	6/25/09, 1910	--	--	--	--	--	--	--	--

TABLE 2-2. ANALYTICAL REQUIREMENTS FOR SEDIMENT, WATER, AND TISSUE SAMPLES

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Sample Type	Total Number of Samples	QC Samples	Parameter(s)	Responsible Laboratory	Sample Volume Required	Container	Holding Time	Preservative	Extraction/Analysis Methodologies	Site Criteria
North Union Lake										
Sediment	1	1 field duplicate	Arsenic Total	USEPA DESA	1 x 250 g	Rigid Plastic/Glass, wide mouth	6 months	4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	5 mg/kg
Water	1	1 field duplicate	Arsenic Total	USEPA DESA	1 x 250 ml	Rigid Plastic	6 months	HNO_3 to pH <2, 4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	10 ug/L
Fish	10 composite samples	1 MS/MSD set	total inorganic arsenic (As), aresnite (As+3), arsenate (As+5), monomethylarsonic acid (MMA), and dimethylarsinic acid (DMA)	Brooks Rand	1 x 200 g	Zip Lock Bag	24 hours shipping time	4°C or frozen	1632 Rev.A	0.0021 mg/kg
Central Union Lake										
Sediment	1	0	Arsenic Total	USEPA DESA	1 x 250 g	Rigid Plastic/Glass, wide mouth	6 months	4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	5 mg/kg
Water	1	0	Arsenic Total	USEPA DESA	1 x 250 ml	Rigid Plastic	6 months	HNO_3 to pH <2, 4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	10 ug/L
Fish	9 composite samples	1 MS/MSD set	total inorganic arsenic (As), aresnite (As+3), arsenate (As+5), monomethylarsonic acid (MMA), and dimethylarsinic acid (DMA)	Brooks Rand	1 x 200 g	Zip Lock Bag	24 hours shipping time	4°C or frozen	1632 Rev.A	0.0021 mg/kg
South Union Lake										
Sediment	1	1 MS/MSD set	Arsenic Total	USEPA DESA	1 x 250 g	Rigid Plastic/Glass, wide mouth	6 months	4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	5 mg/kg
Water	1	1 MS/MSD set	Arsenic Total	USEPA DESA	1 x 250 ml	Rigid Plastic	6 months	HNO_3 to pH <2, 4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	10 ug/L
Fish	6 composite samples	1 MS/MSD set	total inorganic arsenic (As), aresnite (As+3), arsenate (As+5), monomethylarsonic acid (MMA), and dimethylarsinic acid (DMA)	Brooks Rand	1 x 200 g	Zip Lock Bag	24 hours shipping time	4oC or frozen	1632 Rev.A	0.0021 mg/kg
Above the Blackwater Confluence										
Sediment	1	0	Arsenic Total	USEPA DESA	1 x 250 g	Rigid Plastic/Glass, wide mouth	6 months	4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	5 mg/kg
Water	1	0	Arsenic Total	USEPA DESA	1 x 250 ml	Rigid Plastic	6 months	HNO_3 to pH <2, 4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	10 ug/L
Fish	3 composite samples	0	total inorganic arsenic (As), aresnite (As+3), arsenate (As+5), monomethylarsonic acid (MMA), and dimethylarsinic acid (DMA)	Brooks Rand	1 x 200 g	Zip Lock Bag	24 hours shipping time	4°C or frozen	1632 Rev.A	0.0021 mg/kg
Below the Blackwater Confluence										
Sediment	1	0	Arsenic Total	USEPA DESA	1 x 250 g	Rigid Plastic/Glass, wide mouth	6 months	4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	5 mg/kg
Water	1	0	Arsenic Total	USEPA DESA	1 x 250 ml	Rigid Plastic	6 months	HNO_3 to pH <2, 4°C	DESA SOP C-116 (Extraction) and DESA SOP C-109 (ICP/AES Method)	10 ug/L
Fish	7 composite samples	1 MS/MSD set	total inorganic arsenic (As), aresnite (As+3), arsenate (As+5), monomethylarsonic acid (MMA), and dimethylarsinic acid (DMA)	Brooks Rand	1 x 200 g	Zip Lock Bag	24 hours shipping time	4°C or frozen	1632 Rev.A	0.0021 mg/kg

QC sample duplicates collected and analyzed for all media at a rate of 10% per sample matrix per analysis per sample event.
Non-aqueous equipment blanks= 1 blank each per day per matrix (5 days blanks)= 10 non-aqueous blanks (5 sediment / 5 tissue processing)
Aqueous equipment blank = 1 blank total for dedicated water pump/tubing

3. RESULTS

3.1 FISH TISSUE

A summary of fish collected in each of the five geographic areas is provided in Table 3-1. Individual fish retained and designated for compositing and analysis are detailed in Table 3-2. Fish species and number of composites analyzed for each species varied by sampling location because each target species and the optimal number of individual fish for each species were not collected in each area. Species and number of composites submitted for each geographic area are summarized below:

Above Blackwater Confluence	Redbreast Sunfish (3 composites)
Below Blackwater Confluence	Largemouth Bass (1 composite) Redbreast Sunfish (3 composites) Yellow Perch (3 composites)
North Union Lake	White Perch (3 composites) Channel Catfish (3 composites) Bluegill Sunfish (3 composites) Largemouth Bass (1 composite)
Central Union Lake	White Perch (3 composites) Channel Catfish (3 composites) Pumpkinseed Sunfish (3 composites)
South Union Lake	Bluegill Sunfish (3 composites) Channel Catfish (3 composites)

Results of the arsenic speciation for each fish composite with validation qualifiers (as applicable) are provided in Table 3-3. Overall, results varied by sampling area and species.

Detected arsenic concentrations were compared to a screening value of 0.0021 mg/kg. The screening value was taken as the October 2007 USEPA Region III Risk-based Concentration (RBC) for consumption of fish. This value is based on the current recommended toxicological data for inorganic (total) arsenic (USEPA 2009). Total inorganic arsenic and arsenite (As^{3+}) were detected in the majority of the composites from each geographic area. All detected concentrations of inorganic (total) arsenic, arsenite (As^{3+}), arsenate (As^{5+}), MMA, and DMA exceeded the RBC.

In general, arsenite (As^{3+}) and inorganic (total) arsenic concentrations were lower in the fish tissue samples from Above the Blackwater Confluence than at the other sampling locations. Arsenate (As^{5+}), MMA, and DMA were not detected in the three replicates from Above the Blackwater Confluence. At the site Below the Blackwater Confluence, each of the arsenic forms was found in each of the three sampled fish species (redbreast sunfish, yellow perch, and largemouth bass). The highest concentrations of arsenite (As^{3+}) and inorganic (total) arsenic in the samples from Below the Blackwater Confluence were up to an order of magnitude higher than the concentrations measured Above the Blackwater Confluence.

Four species - bluegill sunfish, channel catfish, white perch, and largemouth bass - were analyzed from North Union Lake. Arsenic was not detected in the largemouth bass replicate. The highest concentrations of arsenite (As3+) and inorganic (total) arsenic in the three remaining species from North Union Lake were an order of magnitude higher than the concentrations detected in fish tissue from Above the Blackwater Confluence. Similarly, arsenite (As3+) and inorganic (total) arsenic were much higher in tissue samples from Central Union Lake than in tissue samples from Above the Blackwater Confluence. DMA and MMA were infrequently detected in North Union Lake and Central Union fish tissue samples.

In general, arsenite (As3+) and inorganic (total) arsenic concentrations detected in South Union Lake fish tissue were lower than tissue sampled from Below the Blackwater Confluence and the other Union Lake sites.

The analytical reports and accompanying COC forms for the fish tissue are provided in Appendices B and A, respectively.

3.2 SEDIMENT

The results of the total arsenic analysis for the sediment samples are provided in Table 3-4. The results for detected arsenic concentrations in sediment and soil were compared to the Site Clean-up Level of 20 parts per million (ppm or mg/kg). The Site Clean-up Level of 20 ppm is based upon the New Jersey Residential Clean-up Standard for Arsenic. Each of the sediment samples, except the sample from Above the Blackwater Confluence, had an arsenic concentration above the Site Clean-up Level. Arsenic levels at the Maurice River below the Blackwater confluence and in Union Lake ranged from 25 mg/kg to 1,100 mg/kg and exceeded the Site Clean-up Level by factors ranging from 1.25 to 55.

The analytical report and accompanying COC form for the sediment samples is provided in Appendices C and A, respectively.

3.3 WATER

The results of the total arsenic analysis for the water samples are provided in Table 3-4. Detected arsenic concentrations in water samples were compared to the USEPA Drinking Water Criterion for arsenic of 10 parts per billion (ppb or μg/L). Arsenic was not detected in any of the site water samples above the method detection limit (MDL) of 8 μg/L and therefore did not exceed the USEPA Drinking Water Criterion for arsenic.

The analytical report and accompanying COC form for the water samples is provided in Appendices C and A, respectively.

3.4 QA/QC RESULTS

The results for the QA/QC samples, including equipment blanks and field duplicates are provided in Table 3-4 and 3-5, respectively.

3.4.1 Equipment Blanks

Arsenic was not detected at concentrations above the MDL (8 μg/L) in any of the equipment blanks (Table 3-4). Therefore, it is unlikely that any contamination can be attributed to sampling equipment, collection and handling or homogenization equipment.

3.4.2 Duplicates

Duplicate analyses were performed for sediment, site water, and fish tissue matrices (Table 3-5).

Relative percent differences (RPD) were calculated for duplicate samples that had detected concentrations of arsenic. Following the protocol defined in Worksheet 12 of the *UFP/QAPP* (USACE 2009), the RPD was calculated for one sediment sample (NUL-FS09-SED-FD) and for six fish tissue composites (SUL09-BGS-WB-COMPB, SUL09-BGS-WB-COMPA, BBC09-YPH-WB-COMPC, NUL09-BGS-WB-COMPC, NUL09-CHC-WB-COMPC, and CUL09-WTP-WB-COMPA). The RPD was not calculated for the duplicate water sample (NUL-FS-09-WAT-FD) because arsenic was not detected in either the primary sample or the co-located field duplicate sample. According to the *UFP/QAPP* (USACE 2009), the measurement performance criterion for sediment samples and aqueous samples was 25% RPD (QAPP Worksheets 12-1 and 12-2). The measurement performance criterion for the fish tissue was $\leq$ 30% RPD for duplicate values greater than or equal to 5 times the quantitation limit (QL) (QAPP Worksheet 12-3).

The RPD for the sediment duplicate was 10% and met the measurement performance criterion.

Duplicate samples of fish tissue were tested for inorganic (total) arsenic, arsenite (As3+), DMA, and MMA. Arsenate (As5+) was not included in the duplicate evaluation because this concentration is determined by subtraction of arsenite (As 3+) from inorganic (total) arsenic. Two duplicate samples for inorganic (total) arsenic (SUL09-BGS-WB-COMPA and CUL09-WTP-WB-COMPA) and one duplicate sample for DMA (NUL09-BGS-WB-COMPC) did not meet the performance criterion, with RPDs of 45%, 38%, and 93%, respectively (Table 3-5).

3.4.3 MS/MSD Samples

The laboratory's established QC criteria were met for MS and MSD samples for aqueous and sediment samples. MS/MSD results for fish tissue samples that did not meet laboratory QC criteria are qualified (as applicable) in Table 3-3.

TABLE 3-1. ABUNDANCE AND DISTRIBUTION OF FISHES COLLECTED IN THE MAURICE RIVER AND UNION LAKE

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

		Maurice River		Union Lake			Number of
Common Name	**Scientific Name**	**ABC**	**BBC**	**NUL**	**CUL**	**SUL**	**Vouchers**
American eel	*Anquilla rostrata*	4	4	4	1	1	
Gizzard shad	*Dorosoma cepedianum*			4	3		
Alewife	*Alosa pseudoharengus*			1			
White catfish	*Ameiurus catus*		1	2	3	6	
Channel catfish	*Ictalurus punctatus*			18	10	10	
Yellow bullhead	*Ameiurus natalis*	1					
Brown bullhead	*Ameiurus nebulosus*				3	1	
Tadpole madtom	*Noturus gyrinus*	3					1
Brown trout	*Salmo trutta*	1					
Rainbow trout	*Oncorhynchus mykiss*	2					
Brook trout	*Salvelinus fontinalis*	3					
Creek chubsucker	*Erimyzon oblongus*	14	1	12	1		
White sucker	*Catostomus commersoni*				1		
Golden shiner	*Notemigonus crysoleucas*			10	17		
Chain pickerel	*Esox niger*	12	5	3	3	1	3
Eastern mudminnow	*Umbra pygmaea*	2	2				
Pirate perch	*Aphredoderus sayanus*	9	4				2
Yellow perch	*Perca flavescens*		31	32	5	3	
Tessellated darter	*Etheostoma olmstedi*		1				1
White perch	*Morone americana*		3	32	11	16	
Striped bass	*Morone saxatilis*			2	1	1	
Smallmouth bass	*Micropterus dolomieu*					2	
Largemouth bass	*Micropterus salmoides*	5	5	5	1	9	
Black crappie	*Pomoxis nigromaculatus*			2	2		
Mud sunfish	*Acantharcus pomotis*				1		
Bluespotted sunfish	*Enneacanthus gloriosus*	2	1				1
Green sunfish	*Lepomis cyanellus*		1	1			
Redbreast sunfish	*Lepomis auritus*	18	20		2	3	1
Bluegill	*Lepomis macrochirus*		9	34	9	16	
Pumpkinseed	*Lepomis gibbosus*			17	21		
Lepomis hybrid	*Lepomis sp.*			1	1	1	3
	Number of individuals	**76**	**88**	**180**	**96**	**70**	
	Number of species	**13**	**14**	**17**	**19**	**13**	

ABC - Maurice River above Blackwater Branch
BBC - Maurice River below Blackwater Branch
NUL - North end of Union Lake
CUL - Central portion of Union Lake
SUL - South end of Union Lake

Total number of individuals = 510
Total number of species = 31

TABLE 3-2. TISSUE COMPOSITES CREATED FROM FISH COLLECTED IN THE MAURICE RIVER AND UNION LAKE

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Location	Species	Individual ID	Length (mm)	Mass (g)	Date	Time	Composite ID
Above the Blackwater Confluence	Redbreast Sunfish	ABC09-RBS-WB-001	163	89	6/13/2009	1230	ABC09-RBS-WB-COMPA
		ABC09-RBS-WB-003	174	134			
		ABC09-RBS-WB-004	176	114			
		ABC09-RBS-WB-006	145	73			
		ABC09-RBS-WB-014	154	70			
		ABC09-RBS-WB-008	130	42	6/13/2009	1230	ABC09-RBS-WB-COMPB
		ABC09-RBS-WB-010	130	44			
		ABC09-RBS-WB-013	139	53			
		ABC09-RBS-WB-015	137	49			
		ABC09-RBS-WB-016	134	47			
		ABC09-RBS-WB-002	130	42	6/13/2009	1230	ABC09-RBS-WB-COMPC
		ABC09-RBS-WB-005	121	35			
		ABC09-RBS-WB-007	127	39			
		ABC09-RBS-WB-011	122	35			
		ABC09-RBS-WB-012	128	41			
Below the Blackwater Confluence	Largemouth Bass	BBC09-LMB-F-001	352	617	6/24/2009	1135	BBC09-LMB-F-COMPA
		BBC09-LMB-F-002	378	1,114			
		BBC09-LMB-F-003	309	489			
		BBC09-LMB-F-004	342	636			
	Redbreast Sunfish	BBC09-RBS-WB-009	176	142	6/24/2009	1135	BBC09-RBS-WB-COMPA
		BBC09-RBS-WB-010	171	132			
		BBC09-RBS-WB-011	195	180			
		BBC09-RBS-WB-002	150	70	6/24/2009	1135	BBC09-RBS-WB-COMPB
		BBC09-RBS-WB-003	170	116			
		BBC09-RBS-WB-004	154	86			
		BBC09-RBS-WB-005	174	133			
		BBC09-RBS-WB-001	111	33	6/24/2009	1135	BBC09-RBS-WB-COMPC
		BBC09-RBS-WB-006	122	39			
		BBC09-RBS-WB-007	114	34			
		BBC09-RBS-WB-008	112	37			
		BBC09-RBS-WB-012	105	28			
	Yellow Perch	BBC09-YPH-WB-006	204	108	6/24/2009	1340	BBC09-YPH-WB-COMPA
		BBC09-YPH-WB-007	220	140			
		BBC09-YPH-WB-010	208	123			
		BBC09-YPH-WB-001	187	96	6/24/2009	1340	BBC09-YPH-WB-COMPB
		BBC09-YPH-WB-002	179	75			
		BBC09-YPH-WB-005	181	79			
		BBC09-YPH-WB-003	168	57	6/24/2009	1340	BBC09-YPH-WB-COMPC
		BBC09-YPH-WB-004	164	55			
		BBC09-YPH-WB-008	155	53			
		BBC09-YPH-WB-009	162	51			
		BBC09-YPH-WB-011	165	56			

TABLE 3-2. (continued)

Location	Species	Individual ID	Length (mm)	Mass (g)	Date	Time	Composite ID
North Union Lake	White Perch	NUL09-WTP-WB-001	240	198	6/10/2009	0840	NUL09-WTP-WB-COMPA
		NUL09-WTP-WB-002	260	270			
		NUL09-WTP-WB-012	244	217			
		NUL09-WTP-WB-013	253	227			
		NUL09-WTP-WB-003	205	114	6/10/2009	0840	NUL09-WTP-WB-COMPB
		NUL09-WTP-WB-004	226	182			
		NUL09-WTP-WB-005	215	142			
		NUL09-WTP-WB-010	237	199			
		NUL09-WTP-WB-006	203	119	6/10/2009	0840	NUL09-WTP-WB-COMPC
		NUL09-WTP-WB-007	188	81			
		NUL09-WTP-WB-008	184	80			
		NUL09-WTP-WB-009	197	98			
		NUL09-WTP-WB-011	183	74			
	Channel Catfish	NUL09-CHC-WB-001	510	1,605	6/10/2009	0840	NUL09-CHC-WB-COMPA
		NUL09-CHC-WB-002	533	1,657			
		NUL09-CHC-WB-005	529	1,682			
		NUL09-CHC-WB-004	445	1,029	6/10/2009	0840	NUL09-CHC-WB-COMPB
		NUL09-CHC-WB-007	473	1,205			
		NUL09-CHC-WB-008	497	1,344			
		NUL09-CHC-WB-003	429	993	6/10/2009	0840	NUL09-CHC-WB-COMPC
		NUL09-CHC-WB-006	439	1,045			
		NUL09-CHC-WB-009	435	853			
	Bluegill Sunfish	NUL09-BGS-WB-004	202	140	6/11/2009	1530	NUL09-BGS-WB-COMPA
		NUL09-BGS-WB-006	210	200			
		NUL09-BGS-WB-008	223	222			
		NUL09-BGS-WB-010	204	141			
		NUL09-BGS-WB-011	208	200			
		NUL09-BGS-WB-001	189	119	6/11/2009	1530	NUL09-BGS-WB-COMPB
		NUL09-BGS-WB-005	197	158			
		NUL09-BGS-WB-007	198	142			
		NUL09-BGS-WB-015	190	145			
		NUL09-BGS-WB-016	193	161			
		NUL09-BGS-WB-002	185	117	6/11/2009	1530	NUL09-BGS-WB-COMPC
		NUL09-BGS-WB-003	183	112			
		NUL09-BGS-WB-009	165	96			
		NUL09-BGS-WB-012	177	110			
		NUL09-BGS-WB-014	157	78			
	Largemouth Bass	NUL09-LMB-F-001	335	653	6/11/2009	1530	NUL09-LMB-F-COMPA
		NUL09-LMB-F-003	413	985			
		NUL09-LMB-F-004	401	1,040			
Central Union Lake	White Perch	CUL09-WTP-WB-001	259	242	6/11/2009	0910	CUL09-WTP-WB-COMPA
		CUL09-WTP-WB-003	264	272			
		CUL09-WTP-WB-004	257	242			
		CUL09-WTP-WB-007	249	261	6/11/2009	0910	CUL09-WTP-WB-COMPB
		CUL09-WTP-WB-008	252	227			
		CUL09-WTP-WB-009	246	212			

TABLE 3-2. (continued)

Location	Species	Individual ID	Length (mm)	Mass (g)	Date	Time	Composite ID
Central Union Lake	White Perch	CUL09-WTP-WB-002	210	140	6/11/2009	0910	CUL09-WTP-WB-COMPC
		CUL09-WTP-WB-005	246	214			
		CUL09-WTP-WB-006	240	210			
	Channel Catfish	CUL09-CHC-WB-004	595	2,477	6/11/2009	0910	CUL09-CHC-WB-COMPA
		CUL09-CHC-WB-008	577	1,809			
		CUL09-CHC-WB-009	640	2,755			
		CUL09-CHC-WB-001	520	1,353	6/11/2009	0910	CUL09-CHC-WB-COMPB
		CUL09-CHC-WB-005	575	1,540			
		CUL09-CHC-WB-006	525	1,722			
		CUL09-CHC-WB-002	512	1,506	6/11/2009	0910	CUL09-CHC-WB-COMPC
		CUL09-CHC-WB-003	490	1,380			
		CUL09-CHC-WB-007	505	1,549			
	Pumpkinseed Sunfish	CUL09-PSS-WB-004	180	117	6/12/2009	1120	CUL09-PSS-WB-COMPA
		CUL09-PSS-WB-006	191	144			
		CUL09-PSS-WB-010	185	142			
		CUL09-PSS-WB-001	175	114	6/12/2009	1120	CUL09-PSS-WB-COMPB
		CUL09-PSS-WB-005	179	121			
		CUL09-PSS-WB-009	175	103			
		CUL09-PSS-WB-002	141	62	6/12/2009	1120	CUL09-PSS-WB-COMPC
		CUL09-PSS-WB-003	161	89			
		CUL09-PSS-WB-007	158	75			
		CUL09-PSS-WB-008	155	89			
South Union Lake	Bluegill Sunfish	SUL09-BGS-WB-002	209	179	6/25/2009	1115	SUL09-BGS-WB-COMPA
		SUL09-BGS-WB-006	219	222			
		SUL09-BGS-WB-008	223	268			
		SUL09-BGS-WB-010	232	273			
		SUL09-BGS-WB-004	190	187	6/25/2009	1115	SUL09-BGS-WB-COMPB
		SUL09-BGS-WB-005	195	189			
		SUL09-BGS-WB-007	205	196			
		SUL09-BGS-WB-012	201	198			
		SUL09-BGS-WB-001	154	78	6/25/2009	1115	SUL09-BGS-WB-COMPC
		SUL09-BGS-WB-003	184	117			
		SUL09-BGS-WB-009	176	120			
		SUL09-BGS-WB-011	189	158			
	Channel Catfish	SUL09-CHC-WB-003	530	1,594	6/25/2009	0815	SUL09-CHC-WB-COMPA
		SUL09-CHC-WB-006	502	972			
		SUL09-CHC-WB-009	503	1,488			
		SUL09-CHC-WB-004	495	1,324	6/25/2009	0815	SUL09-CHC-WB-COMPB
		SUL09-CHC-WB-005	482	850			
		SUL09-CHC-WB-007	475	970			
		SUL09-CHC-WB-001	415	848	6/25/2009	0815	SUL09-CHC-WB-COMPC
		SUL09-CHC-WB-002	451	1,024			
		SUL09-CHC-WB-008	435	1,158			

TABLE 3-3. ARSENIC CONCENTRATIONS IN FISH TISSUE COMPOSITES

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Sample ID	Fish Species	Date/Time Collected	Units	As(Inorg) (Total Arsenic)	As(III)	As(V)	DMA	MMA
Above the Blackwater Confluence (ABC)								
ABC09-RBS-WB-COMPA	Redbreast Sunfish	6/13/2009, 1230	MG/KG	**0.006 B**	**0.007 B**	0.005 U	0.003 U	0.005 U
ABC09-RBS-WB-COMPB	Redbreast Sunfish	6/13/2009, 1230	MG/KG	**0.017**	**0.018**	0.005 U	0.003 U	0.005 U
ABC09-RBS-WB-COMPC	Redbreast Sunfish	6/13/2009, 1230	MG/KG	**0.01 B**	**0.014**	0.004 U	0.003 U	0.005 J,U
Below the Blackwater Confluence (BBC)								
BBC09-RBS-WB-COMPA	Redbreast Sunfish	6/24/2009, 1135	MG/KG	**0.064**	**0.064**	0.005 U	**0.007 B**	**0.006 B**
BBC09-RBS-WB-COMPB	Redbreast Sunfish	6/24/2009, 1135	MG/KG	**0.084**	**0.057**	**0.027**	0.003 J,U	0.005 U
BBC09-RBS-WB-COMPC	Redbreast Sunfish	6/24/2009, 1135	MG/KG	**0.131**	**0.109**	**0.022**	**0.008 J,B**	**0.008 B**
BBC09-YPH-WB-COMPA	Yellow Perch	6/24/2009, 1340	MG/KG	**0.074**	**0.061**	**0.013 B**	**0.006 J,B**	0.004 J,U
BBC09-YPH-WB-COMPB	Yellow Perch	6/24/2009, 1340	MG/KG	**0.126**	**0.104**	**0.022**	**0.006 B**	**0.008 B**
BBC09-YPH-WB-COMPC*	Yellow Perch	6/24/2009, 1340	MG/KG	**0.139 JL**	**0.112**	**0.027 B**	**0.028 J**	**0.011 B**
BBC09-LMB-F-COMPA	Largemouth Bass	6/24/2009, 1135	MG/KG	**0.016**	**0.006 B**	**0.01 B**	**0.008 B**	**0.008 B**
North Union Lake (NUL)								
NUL09-BGS-WB-COMPA	Bluegill Sunfish	6/11/2009, 1530	MG/KG	**0.033**	**0.027**	**0.006 B**	0.003 U	0.005 U
NUL09-BGS-WB-COMPB	Bluegill Sunfish	6/11/2009, 1530	MG/KG	**0.105**	**0.099**	**0.006 B**	0.003 U	0.004 U
NUL09-BGS-WB-COMPC*	Bluegill Sunfish	6/11/2009, 1530	MG/KG	**0.195**	**0.184 NL**	**0.011 B**	**0.004 B**	0.005 U
NUL09-CHC-WB-COMPA	Channel Catfish	6/10/2009, 0840	MG/KG	**0.347**	**0.209**	**0.138**	0.003 U	**0.007 B**
NUL09-CHC-WB-COMPB	Channel Catfish	6/10/2009, 0840	MG/KG	**0.021**	**0.035**	0.006 U	0.003 U	0.005 U
NUL09-CHC-WB-COMPC*	Channel Catfish	6/10/2009, 0840	MG/KG	**0.021**	**0.021**	0.005 U	0.003 U	0.004 U
NUL09-WTP-WB-COMPA	White Perch	6/10/2009, 0840	MG/KG	**0.244**	**0.165**	**0.079**	**0.005 B**	**0.011 B**
NUL09-WTP-WB-COMPB	White Perch	6/10/2009, 0840	MG/KG	**0.024**	**0.027**	0.005 U	0.003 U	0.005 U
NUL09-WTP-WB-COMPC	White Perch	6/10/2009, 0840	MG/KG	**0.178**	**0.118**	**0.06**	0.003 U	**0.006 B**
NUL09-LMB-F-COMPA	Largemouth Bass	6/11/2009, 1530	MG/KG	0.003 U	0.004 U	0.004 U	0.003 U	0.005 U
Central Union Lake (CUL)								
CUL09-CHC-WB-COMPA	Channel Catfish	6/11/2009, 0910	MG/KG	**0.01**	**0.007 B**	0.004 U	0.003 U	0.004 U
CUL09-CHC-WB-COMPB	Channel Catfish	6/11/2009, 0910	MG/KG	**0.101**	**0.089**	**0.012 B**	**0.004 B**	0.004 U
CUL09-CHC-WB-COMPC	Channel Catfish	6/11/2009, 0910	MG/KG	**0.096**	**0.072**	**0.024**	0.003 U	0.004 U
CUL09-PSS-WB-COMPA	Pumpkinseed Sunfish	6/12/2009, 1120	MG/KG	**0.105**	**0.101**	0.005 U	**0.005 B**	0.005 U
CUL09-PSS-WB-COMPB	Pumpkinseed Sunfish	6/12/2009, 1120	MG/KG	**0.119**	**0.106**	**0.013 B**	0.003 U	**0.005 J,B**
CUL09-PSS-WB-COMPC	Pumpkinseed Sunfish	6/12/2009, 1120	MG/KG	**0.061**	**0.046**	**0.015**	0.003 U	0.005 U
CUL09-WTP-WB-COMPA*	White Perch	6/11/2009, 0910	MG/KG	**0.107**	**0.044**	**0.063**	0.003 U	0.005 U
CUL09-WTP-WB-COMPB	White Perch	6/11/2009, 0910	MG/KG	**0.028**	**0.011 B**	**0.017**	0.003 U	0.005 U
CUL09-WTP-WB-COMPC	White Perch	6/11/2009, 0910	MG/KG	**0.244**	**0.152**	**0.092**	0.003 U	0.005 U
South Union Lake (SUL)								
SUL09-BGS-WB-COMPA*	Bluegill Sunfish	6/25/2009, 1115	MG/KG	**0.038**	**0.028**	**0.01 B**	0.003 U	0.005 U
SUL09-BGS-WB-COMPB*	Bluegill Sunfish	6/25/2009, 1115	MG/KG	**R**	**0.059**	**0.013 B**	**0.004 B**	0.004 UL
SUL09-BGS-WB-COMPC	Bluegill Sunfish	6/25/2009, 1115	MG/KG	**0.156**	**0.064**	**0.092**	0.003 U	0.005 U
SUL09-CHC-WB-COMPA	Channel Catfish	6/25/2009, 0815	MG/KG	**0.005 B**	0.004 U	**0.005 B**	**0.005 B**	0.005 U
SUL09-CHC-WB-COMPB	Channel Catfish	6/25/2009, 0815	MG/KG	**0.005 B**	**0.007 B**	0.005 U	0.003 J,U	0.005 U
SUL09-CHC-WB-COMPC	Channel Catfish	6/25/2009, 0815	MG/KG	**0.006 B**	0.004 U	**0.006 B**	**0.005 B**	0.005 U

*Sample was also used for duplicate analysis. Results for duplicate analysis provided in Table 3-5.

Notes: Bold values represent detected concentrations

Shaded values represent detected concentrations that exceed the screening value of 0.0021 mg/kg

Method detection limit is shown for non-detected constituents

B = Compound was detected, but below the reporting limit (value is estimated)

J = Detected in the laboratory method blank

N = Spike recovery was not within acceptance criteria. Result is estimated.

U = Compound was not detected

L = Result is biased low

R = Data was rejected by the validator

TABLE 3-4. ARSENIC CONCENTRATIONS IN SEDIMENT AND SITE WATER SAMPLES

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Sampling Location	Sample ID	Date/Time Collected	Units	Screening Value	Concentration
Sediment Samples					
Above the Blackwater Confluence	ABC-FS09-SED	6/25/09, 1451	mg/kg	20	0.68 U
Below the Blackwater Confluence	BBC-FS09-SED	6/24/09, 1540	mg/kg	20	**25**
North Union Lake	NUL-FS09-SED	6/25/09, 1013	mg/kg	20	**1,100**
North Union Lake Field Duplicate	NUL-FS09-SED-FD	6/25/09, 1013	mg/kg	20	**1,000**
Central Union Lake	CUL-FS09-SED	6/25/09, 1040	mg/kg	20	**250**
South Union Lake	SUL-FS09-SED	6/25/09, 1054	mg/kg	20	**280**
Water Samples					
Above the Blackwater Confluence	ABC-FS09-WAT	6/25/09, 1458	ug/L	10	8.0 U
Below the Blackwater Confluence	BBC-FS09-WAT	6/24/09, 1530	ug/L	10	8.0 U
North Union Lake	NUL-FS09-WAT	6/25/09, 1007	ug/L	10	8.0 U
North Union Lake Field Duplicate	NUL-FS09-WAT-FD	6/25/09, 1007	ug/L	10	8.0 U
Central Union Lake	CUL-FS09-WAT	6/25/09, 1030	ug/L	10	8.0 U
South Union Lake	SUL-FS09-WAT	6/25/09, 1048	ug/L	10	8.0 U
Equipment Blanks					
Equipment Blank from Ponar, 24 June 2009	EQBSEDGRAB-062409	6/24/09, 1943	ug/L	--	8.0 U
Equipment Blank from Ponar, 25 June 2009	EQBSEDGRAB-062509	6/25/09, 1910	ug/L	--	8.0 U
Equipment Blank from Water Sampling, 24 June 2009	EQBWAT-062409	6/24/09, 1952	ug/L	--	8.0 U

Notes: Bold values represent detected concentrations

Shaded sediment values represent concentrations that exceed the Site Clean-up Criterion of 20 mg/kg

None of the arsenic concentrations in the water samples exceeded the screening value of 10 ug/L

Reporting limit is shown for non-detected constituents

U = Compound was not detected above the reporting limit

TABLE 3-5. FIELD DUPLICATE SAMPLE RESULTS
VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Sample ID	Analyte	Sample Result (mg/kg)	Duplicate Result (mg/kg)	Relative Percent Difference (RPD)
Sediment				
NUL-FS09-SED	Total Arsenic	1,100	1,000	10%
Site Water				
NUL-FS09-WAT	Total Arsenic	8.0 U*	8.0 U*	NC
Tissue				
SUL09-BGS-WB-COMPB	As(III)	0.059	0.063	7%
	As(Inorg) (total arsenic)	0.072 M	0.061	17%
	DMA	0.004 B	ND	NC
	MMA	ND	ND	NC
SUL09-BGS-WB-COMPA	As(III)	0.028	0.023	20%
	As(Inorg) (total arsenic)	0.038	0.024	45%
	DMA	ND	ND	NC
	MMA	ND	ND	NC
BBC09-YPH-WB-COMPC	As(III)	0.112	0.098	13%
	As(Inorg) (total arsenic)	0.139	0.119	16%
	DMA	0.028	0.032	13%
	MMA	0.011	0.010	10%
NUL09-BGS-WB-COMPC	As(III)	0.184 N	0.213	15%
	As(Inorg) (total arsenic)	0.195	0.156	22%
	DMA	0.004 B	0.011	93%
	MMA	ND	0.006	NC
NUL09-CHC-WB-COMPC	As(III)	0.021	0.017	21%
CUL09-WTP-WB-COMPA	As(Inorg) (total arsenic)	0.107	0.077	38%
	DMA	ND	ND	NC
	MMA	ND	ND	NC

* sample was measured in µg/L

NC = Not calculated

ND = Not detected

B = Compound was detected, but below the reporting limit (value is estimated)

J = Detected in the laboratory method blank

M = Duplicate precision (RPD) was not within acceptance criteria. Result is estimated.

N = Spike recovery was not within acceptance criteria. Result is estimated.

U = Compound was not detected

4. RISK EVALUATION

This risk evaluation was undertaken to assess arsenic that has migrated downstream from the Vineland Superfund Site. The focus of the evaluation was on recreational anglers who may catch and consume fish from the Maurice River or from Union Lake.

Currently, a fish advisory is in effect for Union Lake; however this advisory is not based on arsenic levels. Although there is a fish advisory, some anglers may still consume fish from the lake. This evaluation represents a reasonable maximum exposure scenario for anglers who may consume fish from the river or lake and provides an estimate of potential risk to these anglers from arsenic in fish.

Fish were collected from 5 locations for this evaluation. Two areas were sampled in the Maurice River, one below the confluence of Blackwater Branch and one above the confluence (to serve as a reference). Three locations/areas were sampled in Union Lake, one in the northern portion, one in the southern portion, and one in the central portion. Seven different species of fish were analyzed for arsenic. Based on fish distribution during sampling, not all species were found at each sampling area/location. Fish samples were taken as whole body samples with the exception of largemouth bass (fillet). A summary of the sampling results (arsenic concentrations in tissue) is provided in Table 4-1.

4.1 SCREENING ANALYSIS

Inorganic (total) arsenic results were compared to the USEPA Region III risk-based concentration (RBC) for fish (USEPA 2007) in a screening analysis. This value is 0.0021 mg/kg. Detected concentrations of arsenic in fish tissue were quite high; all of the species sampled in each location/area including the reference area (above the Blackwater Branch confluence) exceeded the screening value.

4.2 TOXICITY ANALYSIS

This risk evaluation focused on inorganic (total) arsenic because recommended toxicological values for other arsenic species were not available (USEPA 2009). Not all forms of arsenic have the same toxicity. While inorganic (total) arsenic is considered highly toxic, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) are considered much less toxic.

The toxicological parameters recommended by USEPA for inorganic (total) arsenic have not changed since before the derivation of the screening value (USEPA 2009). Arsenic is classified as a known human carcinogen; arsenic exposure can also produce non-carcinogenic effects (USEPA 2009). Therefore risk calculations for arsenic are performed as both a carcinogen and as a non-carcinogen.

4.3 EXPOSURE ANALYSIS

In the exposure assessment, the human population, or groups of individuals potentially exposed to the contaminant of potential concern (i.e., potential human receptors) were characterized.

Although there is a current advisory against consuming fish from Union Lake, people from the local population or visitors to the area may consume fish caught from the Maurice River or Union Lake. This evaluation focuses on the most conservative scenario of these anglers, those who would consume all of their fish from the sampled area.

Exposure parameters for recreational anglers were taken from USEPA guidance (USEPA 1989b, 1997). A child (aged 0-6 years) and an adult recreational angler were evaluated. Although very young children are not expected to fish regularly, they may consume fish brought home from a parent who enjoys recreational fishing. Exposure parameters for the adult and child recreational anglers are provided in Tables 4-2 and 4-3.

4.4 RISK CHARACTERIZATION

Risks were calculated for inorganic (total) arsenic based on current recommended toxicity values by USEPA (USEPA 2009). The exposure point concentration for all species is based on the maximum detected concentration as a conservative measure. Table 4-4 presents the risk calculations for the adult recreational angler. Table 4-5 presents the risk calculations for the child recreational angler. The location on these tables for Union Lake combined presents the maximum value detected for the three sampling areas of the lake. The maximum was utilized as there are too few samples to conduct reliable statistics on the data; the maximum also provides a conservative estimate of the exposure point concentration for the lake as a whole.

Risk calculations were performed for each species sampled at each location. Table 4-6 provides a summary of the risk evaluation results. Inorganic (total) arsenic cancer risks are above the 1E-4 to 1E-6 acceptable risk range for all species with arsenic detections and all areas, including the reference area. Non-carcinogenic hazard quotients for inorganic (total) arsenic are calculated above the threshold of 1.0 with the exception of channel catfish in south Union Lake and redbreast sunfish in the reference area. These results indicate a potential concern for consumption of fish in the Maurice River and Union Lake due to arsenic.

4.5 UNCERTAINTY ANALYSIS

An uncertainty analysis was performed to analyze the potential bias in assumptions made in the risk calculation process.

The data used in the calculations were validated according to USEPA methods. The validation revealed that some data points may have been biased high. Use of these data in the risk calculations may bias the risk results high as well.

The evaluation focused on inorganic (total) arsenic in that it is the only arsenic species with an USEPA recommended toxicity value. The focus on inorganic (total) arsenic, not including the less toxic forms of arsenic detected in the fish, may bias the results high. However, as MMA and DMA were not detected or were detected in much lower amounts than inorganic (total) arsenic, this bias is not expected to be significant.

The calculations assume that fish ingestion for local anglers is an upper-bound (95%) of fish ingestion as documented in surveys compiled by USEPA (USEPA 1997). The upper-bound ingestion rate used in this estimate was 26 g/day; the mean ingestion rate was 8.7 g/day (USEPA 1997). These assumptions may bias the results high because the consumption of this quantity of fish from the sampling area is unlikely given the current advisory restrictions.

It is also conservative to assume that 100% of the fish ingested by local anglers is from one area/location and is limited to one species. It is likely that anglers would consume a variety of fish species and that over their lifetime they would consume fish from different areas in Union Lake and the Maurice River; this assumption may bias the results high. For species that bioaccumulate arsenic at higher rates, this may also bias the results high.

4.6 SUMMARY OF RISK EVALUATION

This evaluation provides a risk-based estimate of potential risks from arsenic exposure through ingestion of fish from the Maurice River and Union Lake below the confluence of Blackwater Branch. Conservative assumptions were made throughout the risk evaluation to provide a reasonable maximum estimate of risks. Arsenic was detected in high levels in the fish sampled at all areas/locations. The risk estimates exceed acceptable standards (1E-4 to 1E-6 range for carcinogenic effects; 1.0 for non-carcinogenic effects) to such a degree that lowering the conservative factors in the calculations would not achieve acceptable risk levels.

TABLE 4-1. MAXIMUM MEASURED CONCENTRATION, RANGE OF DETECTION LIMITS, AND FREQUENCY OF DETECTION IN FISH TISSUE COMPOSITES COLLECTED FROM THE MAURICE RIVER AND UNION LAKE

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

	As(Inorg) (Total Arsenic)			As(III)			As(V)			DMA			MMA		
	Maximum Detection (mg/kg)	Range of Detection Limits	Detection Frequency	Maximum Detection (mg/kg)	Range of Detection Limits	Detection Frequency	Maximum Detection (mg/kg)	Range of Detection Limits	Detection Frequency	Maximum Detection (mg/kg)	Range of Detection Limits	Detection Frequency	Maximum Detection (mg/kg)	Range of Detection Limits	Detection Frequency
TESTED SPECIES															
Below the Blackwater Confluence (BBC)															
Largemouth Bass	0.016	0.016	1/1	0.006 B	0.006	1/1	0.01 B	0.01	1/1	0.008 B	0.008	1/1	0.008 B	0.008	1/1
Redbreast Sunfish	0.131	0.064-0.131	3/3	0.109	0.057-0.109	3/3	0.027	0.005-0.027	2/3	0.008 J, B	0.003-0.008	2/3	0.008 B	0.005-0.008	2/3
Yellow Perch	0.139	0.074-0.139	3/3	0.112	0.061-0.112	3/3	0.027 B	0.013-0.027	3/3	0.028 J	0.006-0.028	3/3	0.011 B	0.004-0.011	2/3
North Union Lake (NUL)															
Bluegill Sunfish	0.195	0.033-0.195	3/3	0.184 N	0.027-0.184	3/3	0.011 B	0.006-0.011	3/3	0.004 B	0.003-0.004	1/3	ND	-	0/3
Channel Catfish	0.347	0.021-0.347	3/3	0.209	0.021-0.209	3/3	0.138	0.005-0.138	1/3	ND	-	0/3	0.007 B	0.004-0.007	1/3
Largemouth Bass	ND	-	1/1	ND	-	1/1	ND	-	1/1	ND	-	1/1	ND	-	1/1
White Perch	0.244	0.024-0.244	3/3	0.165	0.027-0.165	3/3	0.079	0.005-0.079	2/3	0.005 B/B	0.003-0.005	1/3	0.011 B	0.005-0.011	2/3
Central Union Lake (CUL)															
Channel Catfish	0.101	0.01-0.101	3/3	0.089	0.007-0.089	3/3	0.024	0.004-0.024	2/3	0.004 B/B	0.003-0.004	1/3	ND	-	3/3
Pumpkinseed Sunfish	0.119	0.061-0.119	3/3	0.106	0.046-0.106	3/3	0.015	0.005-0.015	2/3	0.005 B	0.003-0.005	1/3	0.005 B/J, B	0.005-0.005	1/3
White Perch	0.244	0.028-0.244	3/3	0.152	0.011-0.152	3/3	0.092	0.017-0.092	3/3	ND	-	3/3	ND	-	3/3
South Union Lake (SUL)															
Bluegill Sunfish	0.156	0.038-0.156	2/2(1)	0.064	0.028-0.064	3/3	0.092	0.01-0.092	3/3	0.004 B	0.003-0.004	1/3	ND	-	3/3
Channel Catfish	0.006 B	0.005-0.006	3/3	0.007 B	0.004-0.007	1/3	0.006 B	0.005-0.006	2/3	0.005 B/B	0.003-0.005	2/3	ND	-	3/3
Above the Blackwater Confluence (ABC) - Reference															
Redbreasted Sunfish	0.017	0.006-0.017	3/3	0.018	0.007-0.018	3/3	ND	-	3/3	ND	-	3/3	ND	-	3/3

(1) Sample SUL09-BGS-WB-COMPB was rejected by the validator and therefore not included in this assessment.

MDL = method detection limit

DMA = dimethyl arsenic

MMA = monomethyl arsenic

B = Lab qualifier indicating that this concentration is

ND = Lab qualifier indicating a the analyte was not detected in any sample.

N = Lab qualifier indicating

J = Lab qualifier indicating estimated value.

TABLE 4-2. EXPOSURE VALUES FOR RECREATIONAL ADULT ANGLER FISH INTAKE

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Scenario Timeframe: Future Medium: Fish Exposure Medium: Fish Exposure Point: Vineland, NJ Receptor Population: Recreational Angler Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation / Model Name
Ingestion	C	Chemical Concentration in Fish	mg/kg	Species-Specific	Species-Specific	Chronic Daily Intake (CDI) (mg/kg/day) = C x CR x EF X ED / (CF X BW X AT)
	CR	Ingestion Rate(1)	g/day	26	USEPA 1997	
	EF	Exposure Frequency(2)	day/yr	365	USEPA 1989	
	ED	Exposure Duration	yr	24	USEPA 1989	
	BW	Body Weight	kg	70	USEPA 1989	
	AT	Averaging Time, carcinogens	days	25,550	USEPA 1989	
	CF	Conversion Factor	g/kg	1,000		

(1) Ingestion rate taken as the upper bound (95th percentile) daily intake for freshwater recreational anglers (USEPA 1997. Volume II, Chapter 10).
(2) Exposure frequency is every day of the year as based on the ingestion rate.

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (Interim Final). Report No. EPA/540/1 89/002. Office of Emergency and Remedial Response, Washington, DC. December.
USEPA 1997. Exposure Factors Handbook: Volumes I, II, and III. EPA/600/P-95/002a,b,c. August.

TABLE 4-3. EXPOSURE VALUES FOR RECREATIONAL CHILD ANGLER FISH INTAKE

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Scenario Timeframe: Current/Future Medium: Fish Exposure Medium: Fish Exposure Point: Vineland, NJ Receptor Population: Recreational Angler Receptor Age: Child

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/Reference	Intake Equation / Model Name
Ingestion	C	Chemical Concentration in Fish	mg/kg	Species-Specific	Species-Specific	CDI (mg/kg/day) =
	CR	Ingestion Rate(1)	g/day	8.67	BPJ(3)	C x CR x EF X ED / (CF X BW X AT)
	EF	Exposure Frequency(2)	day/yr	365	USEPA 1989	
	ED	Exposure Duration	yr	6	USEPA 1989	
	BW	Body Weight	kg	15	USEPA 1989	
	AT	Averaging Time, carcinogens	days	25,550	USEPA 1989	
	CF	Conversion Factor	g/kg	1,000		

Note : BPJ = Best Professional Judgment

(1) Ingestion rate taken as the one third of the daily intake for freshwater adult recreational anglers (USEPA 1997. Volume II, Chapter 10).

(2) Exposure frequency is every day of the year as based on the ingestion rate.

(3) Based on one third of the adult ingestion rate.

USEPA 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (Interim Final). Report No. EPA/540/1 89/002. Office of Emergency and Remedial Response, Washington, DC. December.

USEPA 1997. Exposure Factors Handbook: Volumes I, II, and III. EPA/600/P-95/002a,b,c. August.

TABLE 4-4. CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
ADULT ANGLER FISH INGESTION

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Scenario Timeframe: Current/Future
Receptor Population: Adult Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Fish Species	Exposure Point Concentration		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk	Intake/Exposure Concentration		RfD		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish	Fish Tissue	Below Blackwater Confluence	Ingestion													
				Largemouth Bass	0.016	(mg/kg)	2.04E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	3.06E-03	5.94E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.98E+01
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	0.139	(mg/kg)	1.77E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.66E-02	5.16E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.72E+02
				Channel Catfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	0.131	(mg/kg)	1.67E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.50E-02	4.87E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.62E+02
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		North Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	3.11E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	4.66E-02	9.06E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.02E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	3.47E-01	(mg/kg)	4.42E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	6.63E-02	1.29E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	4.30E+02
				Bluegill Sunfish	1.95E-01	(mg/kg)	2.48E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	3.72E-02	7.24E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.41E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Central Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	3.11E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	4.66E-02	9.06E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.02E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	1.01E-01	(mg/kg)	1.29E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.93E-02	3.75E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.25E+02
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	1.19E-01	(mg/kg)	1.52E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.27E-02	4.42E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.47E+02
		South Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	0.006	(mg/kg)	7.64E-04	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.15E-03	2.23E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	7.43E+00
				Bluegill Sunfish	1.56E-01	(mg/kg)	1.99E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.98E-02	5.79E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.93E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Union Lake combined	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	3.11E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	4.66E-02	9.06E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.02E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	3.47E-01	(mg/kg)	4.42E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	6.63E-02	1.29E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	4.30E+02
				Bluegill Sunfish	1.95E-01	(mg/kg)	2.48E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	3.72E-02	7.24E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.41E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Above Blackwater Confluence	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	1.70E-02	(mg/kg)	2.16E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	3.25E-03	6.31E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.10E+01
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--

Exposure Point Concentration (EPC) taken as the maximum detected concentration.
CSF = Cancer Slope Factor
RfD = Reference Dose
Toxicity Values taken from Integrated Risk Information System (USEPA 2009)

TABLE 4-5. CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
CHILD ANGLER FISH INGESTION

VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Scenario Timeframe: Current/Future
Receptor Population: Child Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Fish Species	Exposure Point Concentration		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk	Intake/Exposure Concentration		RfD		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Fish	Fish Tissue	Below Blackwater Confluence	Ingestion													
				Largemouth Bass	0.016	(mg/kg)	7.92E-04	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.19E-03	9.24E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.08E+01
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	0.139	(mg/kg)	6.88E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.03E-02	8.03E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.68E+02
				Channel Catfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	0.131	(mg/kg)	6.49E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	9.73E-03	7.57E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.52E+02
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		North Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	1.21E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.81E-02	1.41E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	4.70E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	3.47E-01	(mg/kg)	1.72E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.58E-02	2.00E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	6.68E+02
				Bluegill Sunfish	1.95E-01	(mg/kg)	9.66E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.45E-02	1.13E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.76E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Central Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	1.21E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.81E-02	1.41E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	4.70E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	1.01E-01	(mg/kg)	5.00E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	7.50E-03	5.84E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.95E+02
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	1.19E-01	(mg/kg)	5.89E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	8.84E-03	6.88E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	2.29E+02
		South Union Lake	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	0.006	(mg/kg)	2.97E-04	(mg/kg-day)	1.50E+00	per (mg/kg-day)	4.46E-04	3.47E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	1.16E+01
				Bluegill Sunfish	1.56E-01	(mg/kg)	7.73E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.16E-02	9.01E-02	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.00E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Union Lake combined	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	2.44E-01	(mg/kg)	1.21E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.81E-02	1.41E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	4.70E+02
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	3.47E-01	(mg/kg)	1.72E-02	(mg/kg-day)	1.50E+00	per (mg/kg-day)	2.58E-02	2.00E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	6.68E+02
				Bluegill Sunfish	1.95E-01	(mg/kg)	9.66E-03	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.45E-02	1.13E-01	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.76E+02
				Redbreast Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
		Above Blackwater Confluence	Ingestion													
				Largemouth Bass	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				White Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Yellow Perch	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Channel Catfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Bluegill Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--
				Redbreast Sunfish	1.70E-02	(mg/kg)	8.42E-04	(mg/kg-day)	1.50E+00	per (mg/kg-day)	1.26E-03	9.82E-03	(mg/kg-day)	3.00E-04	(mg/kg-day)	3.27E+01
				Pumpkinseed Sunfish	NA	(mg/kg)	NA	(mg/kg-day)	1.50E+00	per (mg/kg-day)	--	NA	(mg/kg-day)	3.00E-04	(mg/kg-day)	--

Exposure Point Concentration (EPC) taken as the maximum detected concentration.
CSF = Cancer Slope Factor
RfD = Reference Dose
Toxicity Values taken from Integrated Risk Information System (USEPA 2009)

TABLE 4-6. SUMMARY OF RECEPTOR RISKS AND HAZARDS
REASONABLE MAXIMUM EXPOSURE
CHILD AND ADULT ANGLER FISH INGESTION
VINELAND FISH TISSUE SURVEY, VINELAND, NEW JERSEY, JUNE 2009

Location: Vineland, New Jersey
Scenario Timeframe: Current/Future
Receptor Population: Recreational Angler
Receptor Age: Child and Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			Chemical	Non-Carcinogenic Hazard Quotient		
				Child	Adult	Lifetime (Child + Adult)		Primary Target Organ	Child	Adult
Fish	Fish Tissue	Below Blackwater Confluence	**Fish Species**				**Fish Species**			
			Largemouth Bass	1.2E-03	3.1E-03	4.24E-03	Largemouth Bass	Skin	3.1E+01	2.0E+01
			White Perch	--	--	--	White Perch	Skin	--	--
			Yellow Perch	1.0E-02	2.7E-02	3.69E-02	Yellow Perch	Skin	2.7E+02	1.7E+02
			Channel Catfish	--	--	--	Channel Catfish	Skin	--	--
			Bluegill Sunfish	--	--	--	Bluegill Sunfish	Skin	--	--
			Redbreast Sunfish	9.7E-03	2.5E-02	3.48E-02	Redbreast Sunfish	Skin	2.5E+02	1.6E+02
			Pumpkinseed Sunfish	--	--	--	Pumpkinseed Sunfish	Skin	--	--
		North Union Lake	**Fish Species**				**Fish Species**			
			Largemouth Bass	--	--	--	Largemouth Bass	Skin	--	--
			White Perch	1.8E-02	4.7E-02	6.47E-02	White Perch	Skin	4.7E+02	3.0E+02
			Yellow Perch	--	--	--	Yellow Perch	Skin	--	--
			Channel Catfish	2.6E-02	6.6E-02	9.21E-02	Channel Catfish	Skin	6.7E+02	4.3E+02
			Bluegill Sunfish	1.4E-02	3.7E-02	5.17E-02	Bluegill Sunfish	Skin	3.8E+02	2.4E+02
			Redbreast Sunfish	--	--	--	Redbreast Sunfish	Skin	--	--
			Pumpkinseed Sunfish	--	--	--	Pumpkinseed Sunfish	Skin	--	--
		Central Union Lake	**Fish Species**				**Fish Species**			
			Largemouth Bass	--	--	--	Largemouth Bass	Skin	--	--
			White Perch	1.8E-02	4.7E-02	6.47E-02	White Perch	Skin	4.7E+02	3.0E+02
			Yellow Perch	--	--	--	Yellow Perch	Skin	--	--
			Channel Catfish	7.5E-03	1.9E-02	2.68E-02	Channel Catfish	Skin	1.9E+02	1.3E+02
			Bluegill Sunfish	--	--	--	Bluegill Sunfish	Skin	--	--
			Redbreast Sunfish	--	--	--	Redbreast Sunfish	Skin	--	--
			Pumpkinseed Sunfish	8.8E-03	2.3E-02	3.16E-02	Pumpkinseed Sunfish	Skin	2.3E+02	1.5E+02
		South Union Lake	**Fish Species**				**Fish Species**			
			Largemouth Bass	--	--	--	Largemouth Bass	Skin	--	--
			White Perch	--	--	--	White Perch	Skin	--	--
			Yellow Perch	--	--	--	Yellow Perch	Skin	--	--
			Channel Catfish	4.5E-04	1.1E-03	1.59E-03	Channel Catfish	Skin	1.2E+01	7.4E+00
			Bluegill Sunfish	1.2E-02	3.0E-02	4.14E-02	Bluegill Sunfish	Skin	3.0E+02	1.9E+02
			Redbreast Sunfish	--	--	--	Redbreast Sunfish	Skin	--	--
			Pumpkinseed Sunfish	--	--	--	Pumpkinseed Sunfish	Skin	--	--
		Union Lake combined	**Fish Species**				**Fish Species**			
			Largemouth Bass	--	--	--	Largemouth Bass	Skin	--	--
			White Perch	1.8E-02	4.7E-02	6.47E-02	White Perch	Skin	4.7E+02	3.0E+02
			Yellow Perch	--	--	--	Yellow Perch	Skin	--	--
			Channel Catfish	2.6E-02	6.6E-02	9.21E-02	Channel Catfish	Skin	6.7E+02	4.3E+02
			Bluegill Sunfish	1.4E-02	3.7E-02	5.17E-02	Bluegill Sunfish	Skin	3.8E+02	2.4E+02
			Redbreast Sunfish	--	--	--	Redbreast Sunfish	Skin	--	--
			Pumpkinseed Sunfish	--	--	--	Pumpkinseed Sunfish	Skin	--	--
		Above Blackwater Confluence	**Fish Species**				**Fish Species**			
			Largemouth Bass	--	--	--	Largemouth Bass	Skin	--	--
			White Perch	--	--	--	White Perch	Skin	--	--
			Yellow Perch	--	--	--	Yellow Perch	Skin	--	--
			Channel Catfish	--	--	--	Channel Catfish	Skin	--	--
			Bluegill Sunfish	--	--	--	Bluegill Sunfish	Skin	--	--
			Redbreast Sunfish	1.3E-03	3.2E-03	4.51E-03	Redbreast Sunfish	Skin	3.3E+01	2.1E+01
			Pumpkinseed Sunfish	--	--	--	Pumpkinseed Sunfish	Skin	--	--

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